FINAL REPORT FOR RESEARCH AGREEMENT
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"Test of a Proposed Survey Method for Wolverine, Lynx, Fisher, and Marten in the Bitterroot Mountains, Montana"
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TESTING OF PROPOSED SURVEY METHODS FOR THE DETECTION OF WOLVERINE, LYNX, FISHER, AND AMERICAN MARTEN IN BITTERROOT NATIONAL FOREST.

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Frontpiece. A wolverine recorded along the upper Sweathouse Creek drainage [camera #3] within the Selway-Bitterroot Wilderness, Bitterroot National Forest, February, 1995.

TABLE OF CONTENTS

List of Tables..... iii
List of Figures..... iv
Introduction..... 1
Acknowledgments..... 2
Section 1: Remote-Sensing Camera Survey..... 3
Methods..... 3
Results and Discussion..... 9
Conclusions and Recommendations..... 19
Latency to Detection..... 21
Camera Placement..... 22
Intervals for Checking Camera Stations..... 24
Sensor Range and Restricting the Sensor Field..... 24
Batteries..... 25
Walk Test and Field Notes..... 27
Other Problems Encountered..... 28

Section 2: Tracking Station Survey..... 29
Methods..... 29
Results and Discussion..... 38
Comparison of open and closed tracking stations..... 48
Conclusions and Recommendations..... 55

Section 3: Snow Tracking Survey..... 56
Methods..... 56
Results..... 57
Discussion..... 63
Conclusions and Recommendations..... 71

General Summary and Conclusions..... 77
Literature Cited..... 81

Appendix 1: Camera latency to detection graphics for martens, fishers, and wolverines..... 84

Appendix 2: Species list for Bear Creek, Sweathouse Creek, Big Creek, and Bass Creek drainages on the Bitterroot National Forest..... 88

Appendix 3: Graphic of camera monitoring efficiency... 90

Appendix 4: Graphic of activity patterns for martens, fishers, wolverines, snowshoe hares, and red squirrels..... 92

Appendix 5: Tracking plate latency to detection for fishers and martens..... 94

Appendix 6: Fisher track measurements obtained from prints made on contact paper collected from closed tracking plates..... 97

Appendix 7: Marten track measurements obtained from prints made on contact paper collected from closed tracking plates..... 99

TABLES

1 - Species of forest carnivores detected in 4 drainages on the Bitterroot National Forest using Manley remote-sensing cameras..... 11

2 - Survey duration and actual monitoring time for each of 16 remote-sensing camera stations set out in 4 drainages of the Bitterroot National Forest..... 16

3 - Behavioral information for forest carnivores and prey species obtained from remote-sensing cameras in four drainages on the Bitterroot National Forest..... 19

4 - Latency to detection for marten (*Martes americana*) and fisher (*Martes pennanti*) using open and closed tracking stations to survey 8 1-mile^2 units in 4 drainages on the Bitterroot National Forest..... 39

5 - Bear Creek tracking plate survey results..... 40

6 - Summary statistics of fisher discriminant function scores obtained by applying the discriminant function algorithm of Zielinski and Truex (1995) to fisher tracts on contact paper collected from closed tracking stations in Big Creek and Bear Creek..... 44

7 - Big Creek tracking plate survey results..... 45

8 - Sweathouse Creek tracking plate survey results.. 47

9 - Bass Creek tracking plate survey results..... 49

10 - Individual and population summary statistics for group, stride, and straddle measurements on 7 martens..... 59

11 - Individual and population summary statistics for group, stride, and straddle measurements on 2 fishers..... 59

12 - Summary statistics (means and standard deviations) for track abundance from snow-tracking surveys conducted in 4 drainages on Bitterroot National Forest..... 61

13 - Results of simple linear regression analyzing interactions between predators and prey based on track abundance estimates..... 62

14 - Sources of variability contributing to overall variability of snowtracking data..... 65

15 - Recommendations for controlling for variability in snowtracking surveys..... 68

Track Observation Form..... 75

Snow Tracking and Habitat Form..... 76

FIGURES

1 - Placement of remote-sensing cameras in Bitterroot National Forest, Montana..... 5

2 - Remote-sensing camera station number 3 in Bear Creek drainage..... 6

3 - Remote-sensing camera station number 2 in Sweathouse Creek drainage..... 6

4 - Remote-sensing camera station number 2 in Big Creek drainage..... 7

5 - Remote-sensing camera station number 2 in Bass Creek drainage..... 7

6 - American martens documented from (A) Big Creek, and (B) Bear Creek drainages of Bitterroot NationalForest..... 12

7 - Fisher documented from the Big Creek, Bitterroot National Forest using (A) Manley dual sensor camera unit, and (B) Trailmaster unit..... 13

8 - A wolverine documented in the upper portion of the Sweathouse Creek drainage of Bitterroot National Forest [February 2, 1995; 10:15 - 10:16 a.m.]..... 14

9 - Causes for camera down time presented as percentage of total time down..... 17

10 - Two common prey species (A & B) snowshoe hare in winter and summer pelage, respectively, and (C) red squirrel, routinely recorded in Bitterroot National Forest..... 20

11 - Placement of open and closed tracking plates in Bass Creek drainage..... 30

12 - Placement of open and closed tracking plates in Big Creek drainage..... 31

13 - Placement of open and closed tracking plates in Sweathouse Creek drainage..... 32

14 - Placement of open and closed tracking plates in Bear Creek drainage..... 33

15 - Open tracking station..... 34

16 - Closed tracking station..... 34

17 - Fisher approaching closed tracking plate..... 41

18 - Marten stepping on to open tracking plate..... 41

19 - Right forefoot of representative fisher track illustrating common length (A) and width (B) measurements to which the classification algorithm of Zielinski and Truex (1995) was applied..... 43

20 - Comparison of the cumulative number of open and closed tracking plates visited by marten in Sweathouse Creek and Bass Creek drainages..... 51

INTRODUCTION

More and more often federal and state agencies such as the National Forest Service, the Bureau of Land Management, State Fish and Game Departments, Departments of State Lands, etc., are being called upon to determine the occurrence of rare or sensitive vertebrate species on their holdings. The need for such information is obvious. Management decisions are tightly intertwined with the presence or absence of such species. Though this information is crucial to the land manager it is often unavailable, or at best based upon chance sightings of particular species not necessarily by trained professionals. In large part the reason for the absence of such information is the difficulty in collecting this data in a meaningful form. Sampling for rare vertebrate species, particularly those that may have very large home ranges, has been costly both in man hours and equipment. Furthermore such sampling, in order to be meaningful to the land manager, must have scientific rigor. Species must be accurately identified and their presence clearly correlated with the environment in question, particularly at the landscape level. In order to address these concerns an effort has recently been made to develop standardized sampling procedures which could be used by agency personnel for identifying the presence of four important mid-level forest carnivores: lynx, wolverine, fisher, and American marten (Zielinski and Kucera, 1995).

The following research was designed to test 3 methods proposed by Zielinski and Kucera (1995) for the unobtrusive detection of furbearer species in forested areas: (1) remote sensing employing the use of photographic stations, (2) tracking plates (both enclosed and unenclosed), and (3) snowtracking. All of these methods (or variations of such) have been used previously in numerous studies (e.g., remote cameras, Gysel and Davis, 1956; Dodge and Snyder, 1960; Carter and Slater, 1991; Bull et al., 1992; Jones and Raphael, 1993; Kucera and Barrett, 1993; tracking plates, Mayer, 1957; Barrett, 1983; Taylor and

Raphael, 1988; Bull et al., 1992; snowtracking, see Halfpenny et al., 1995 for a review). However there has been significant variation in the way in which these methods have been applied to previous studies and, with few exceptions, previous research has not attempted to compare the efficacy of the different procedures. In particular, when applied to mid-level forest carnivores such detection requires landscape level monitoring as they are quite capable of moving through, and utilizing, a wide diversity of habitat types.

The Bitterroot National Forest was chosen as one beta-test site for this purpose in part so that this research could be integrated into the larger Bitterroot Ecosystem Management Research Project (BEMRP) in progress. An effort was made to develop an experimental protocol which not only tested the proposed methods but also made an initial attempt to compare presence/absence of these species inside and outside of the wilderness within the Bitterroot National Forest.

Following a discussion of the use and applicability of each method recommendations are provided, where necessary, for modifications of the original protocols as outlined by Zielinski and Kucera (1995).

ACKNOWLEDGMENTS

We would like to acknowledge several individuals who helped during the course of this study. Kenneth R. Furrow, Peter Ziegler, and Scott Tomson volunteered their time and efforts in the field often working under adverse conditions to establish and service camera stations. Elaine Caton provided the use of her climbing equipment. The initial suggestion for this study was provided by Dr. L. Jack Lyon, whose continued interest in, and support for, this research was appreciated.

SECTION 1: REMOTE-SENSING CAMERA SURVEY

Several remote camera systems are currently available. Three of these were discussed by Kucera et al. (1995), these being the 110-style camera, the commercially available Trailmaster® system, and the Manley system produced locally (Tim Manley, Kalispell, MT). The 110-style cameras can be triggered only once and require the subject to complete a very specific act to trigger the camera; the subject must pull the trip wire (Jones and Raphael, 1993). The Trailmaster 1500® uses a receiver (i.e., is not a passive sensor) and so requires very specific sets to draw animals into a 1-cm^2 field (Kucera and Barret, 1993). This limitation makes configuration more difficult and restricts the effective monitoring field. The Manley camera system utilizes a passive infrared and microwave sensor which: 1) monitors a wide and adjustable field; 2) requires both heat and motion to trigger; 3) takes multiple photographs; 4) and requires a less elaborate configuration for set up. The Manley Camera System (MCS) seemed best suited for long-term surveys of forest carnivores based on current information available on remote-sensing cameras. The MCS was chosen for testing the camera survey protocols of Kucera et al. (1995) in the current study.

METHODS

Two Manley dual-sensor remote-sensing cameras (Tim Manley, 524 Eckleberry Drive, Columbia Falls, Montana 59912) were placed in each sample unit ca. 1/2 miles apart (Figures 1-5). Bear creek and Big Creek were surveyed simultaneously from 11/30/94 to 02/06/95. Sweathouse Creek and Bass Creek were surveyed from 01/31/95 to 03/28/95. Camera stations were baited by suspending a front or hind quarter of a road-killed white-tailed deer (*Odocoileus virginianus*) between 2 trees by a rope. Initially, baits were hung ca. 2.5 m from the ground. However, gray jays

(*Perisoreus canadensis*) and Stellar's jays (*Cyanocitta stelleri*) rapidly spent the film while feeding on carcasses which were in sensor range. This situation necessitated raising baits above the sensor field (≥ 3 m above the ground).

After hanging the bait, a string was dangled from the carcass to approximately 1 m above the ground and a 10-cm^2 piece of aluminum foil was tied to the end. The foil provided a visual attractant for felids and a central point for directing the camera's viewing field. Cameras were mounted 2-3 m from the ground by bolting them to a tree. A climbing harness and spikes were used to mount and access cameras. Date and time were set on cameras before going into the field and cameras were fitted with 3-volt lithium batteries and a roll of 36-exposure, 200 ASA color slide or color print film. Stations were scented when set, and rescented every 7 days when checked using commercial trapping lures. Baits were not replaced during the survey period.

After mounting cameras and centering the field of view on the aluminum foil, the sensor field was restricted using magnets to match it to the viewing field. A sign was placed within the viewing field identifying the camera station. The camera was secured to a tree with a cable and padlock and then activated.

The last act before leaving a camera station was the walk test. This involved walking through the sensor field to verify that the sensor was triggering the camera and the camera was exposing and advancing the film. The walk test assured that camera units were functioning properly, and initialized each roll of film with a test photo giving the date and time the station was set or checked. When a camera failed on the walk test, attempts were made to fix the problem. The camera was then retested. If it continued to fail, the camera was replaced with a spare camera. If no spare camera was available, or the system was otherwise irreparable under field conditions, the camera was removed and the station was recorded as being "down" (bait was not monitored) until the problem could be fixed.

Initially all cameras were fitted with new, 12-volt tractor

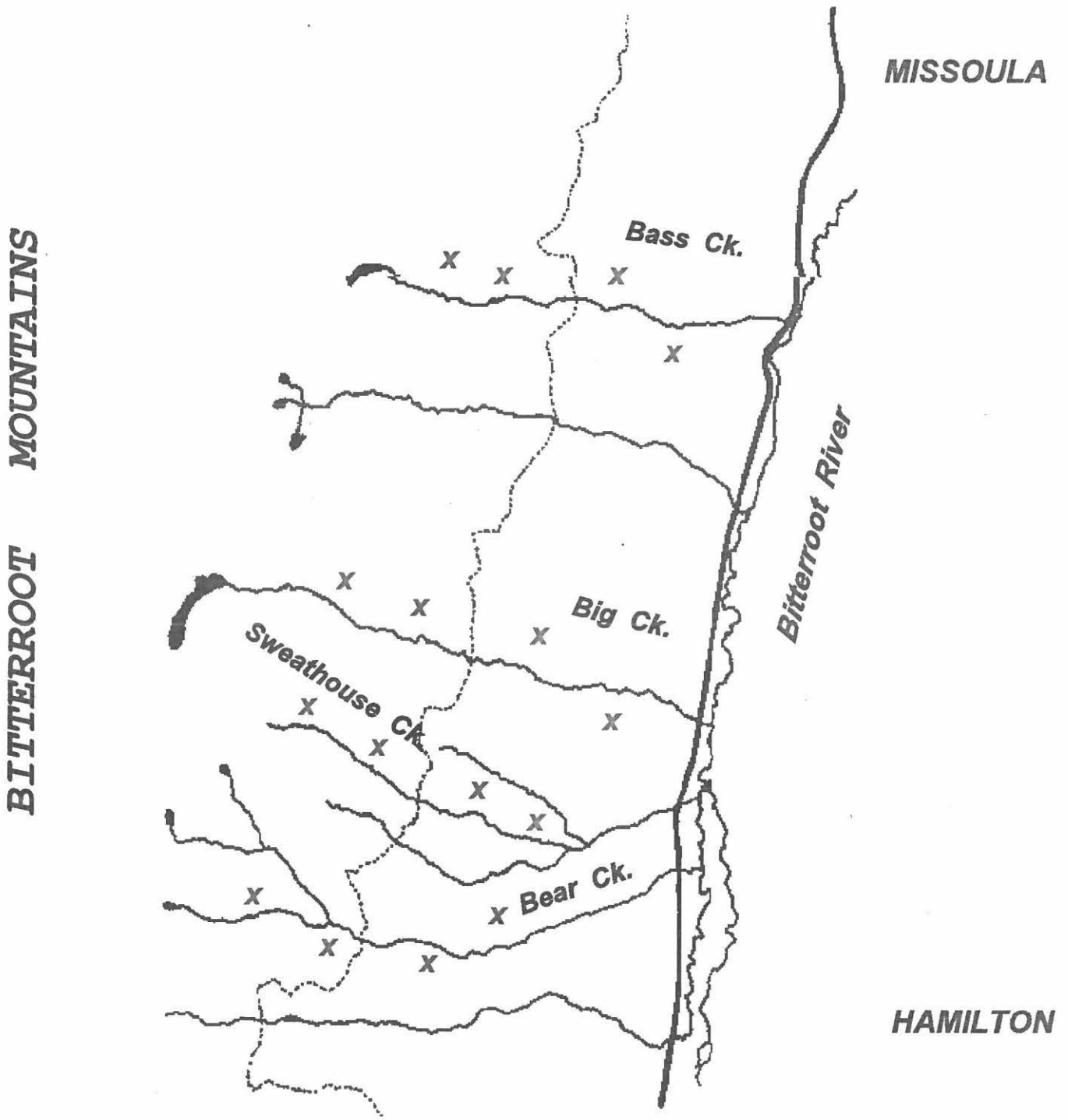


Figure 1. Placement of remote-sensing cameras in Bitterroot National Forest, Montana.

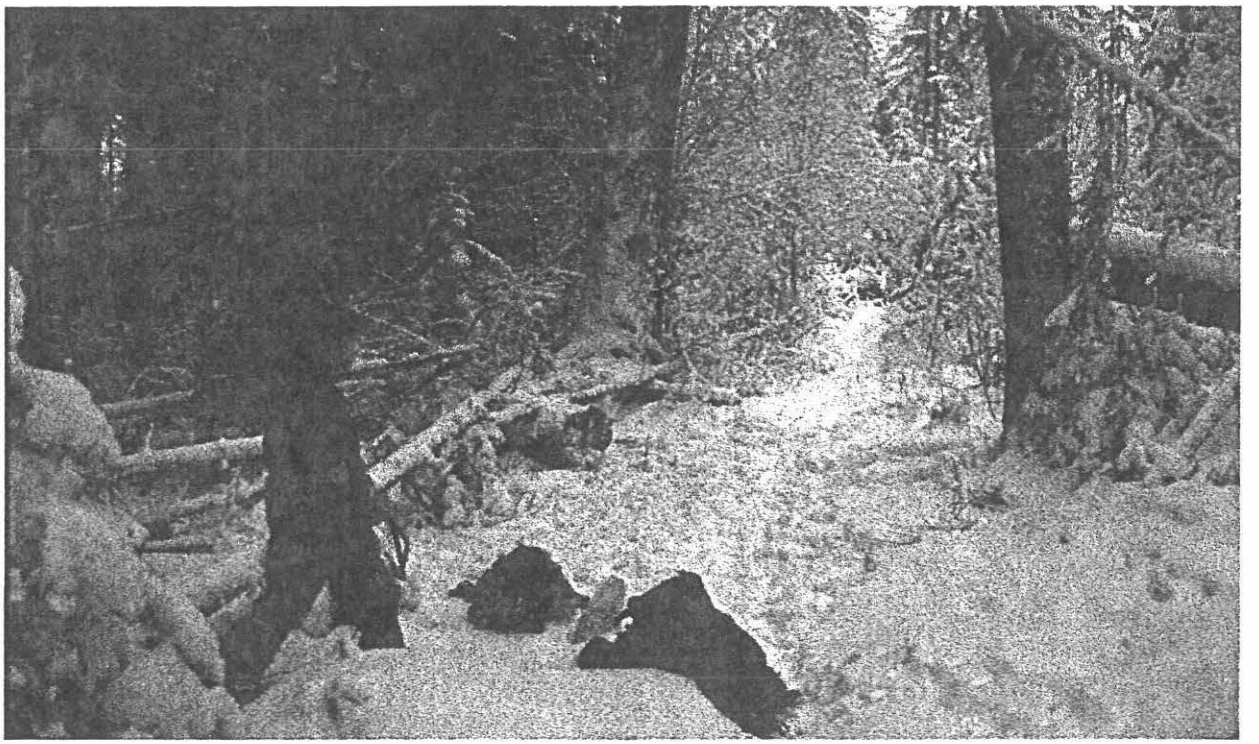


Figure 2. Remote-sensing camera station number 3 in the Bear Creek drainage, Bitterroot National Forest.

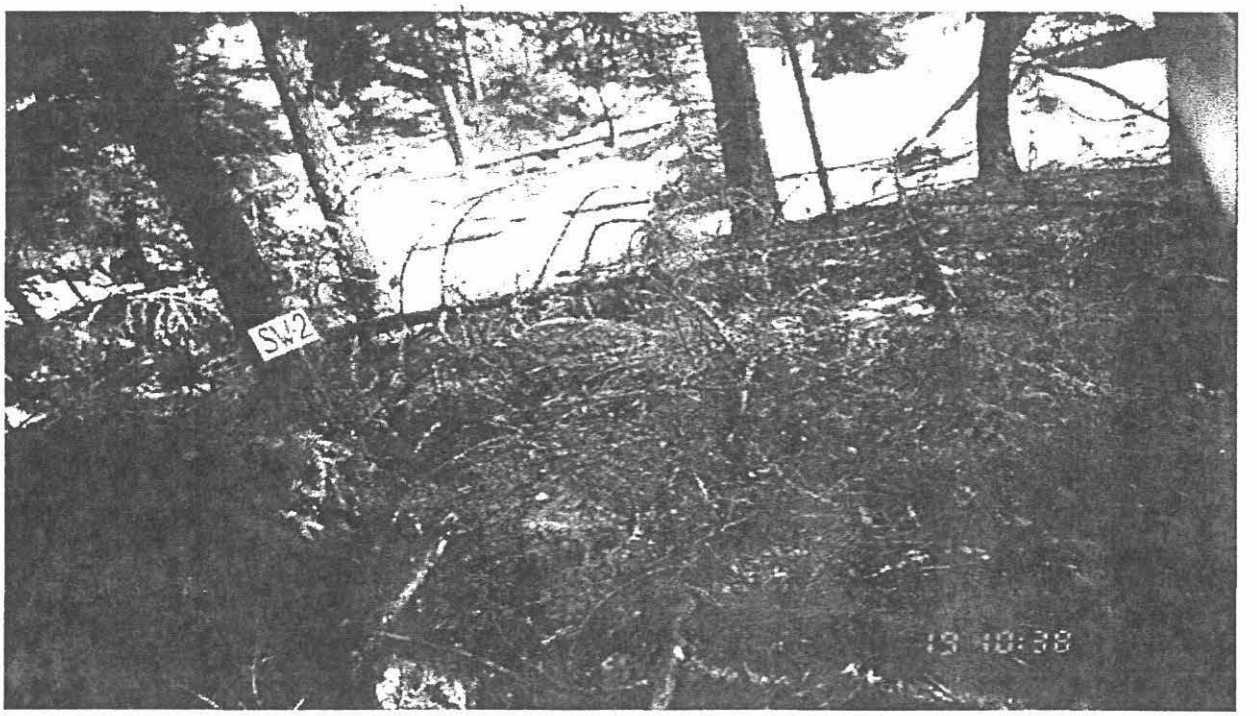


Figure 3. Remote-sensing camera station number 2 in the Sweathouse Creek drainage, Bitterroot National Forest.

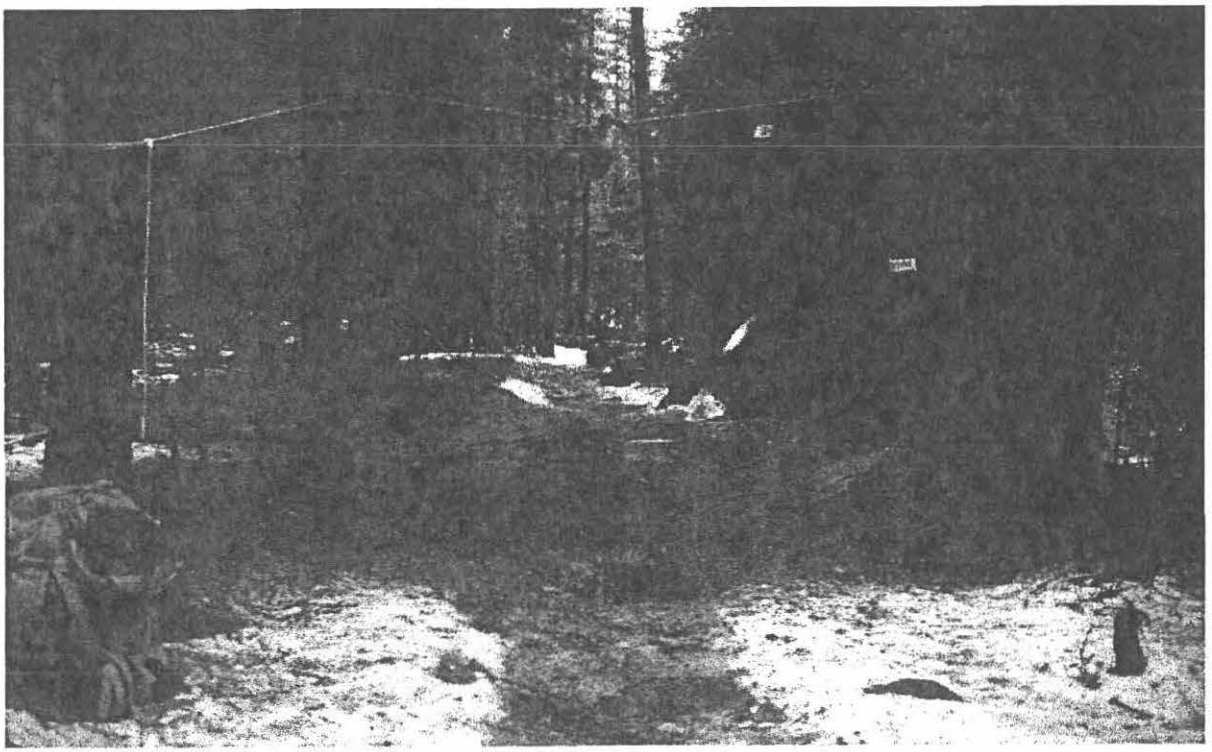


Figure 4. Remote-sensing camera station number 2 in the Big Creek drainage of Bitterroot National Forest.

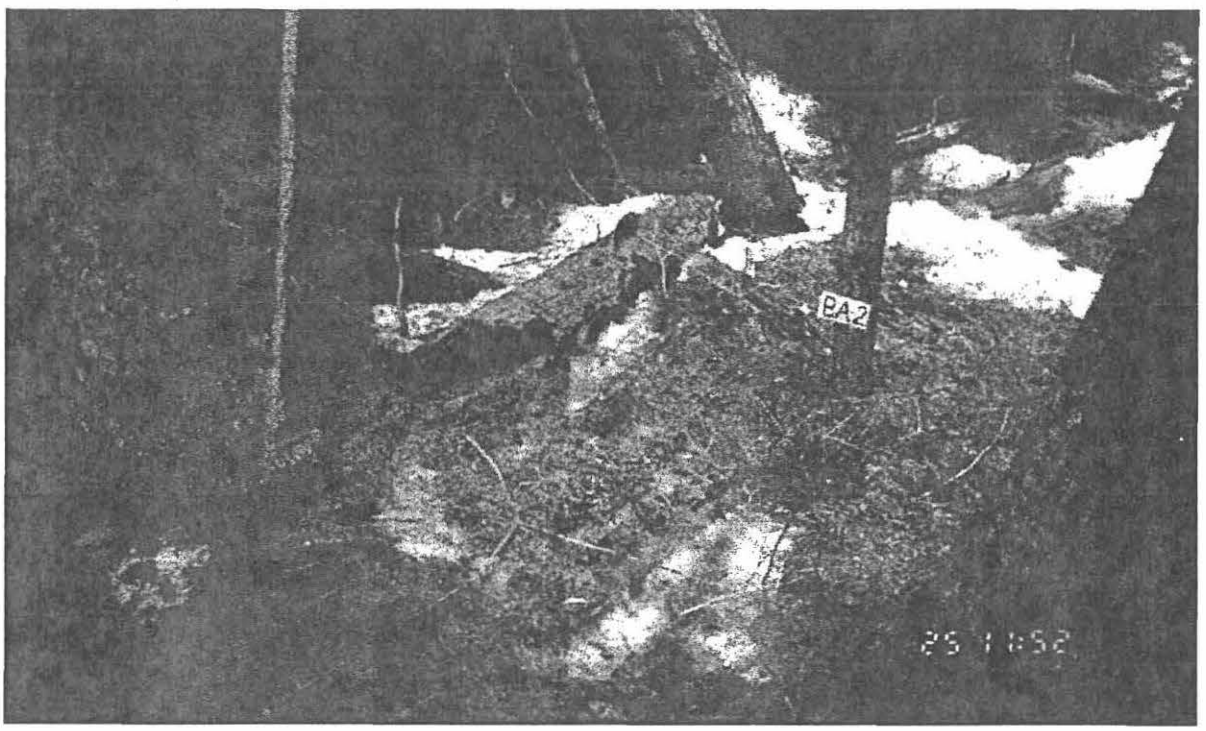


Figure 5. Remote-sensing camera station number 2 in the Bass Creek drainage of Bitterroot National Forest.

batteries (Les Schwab® Power Special Application). When the battery tester indicated that the charge had fallen below 12 volts, batteries were replaced by rotating them with ones which had been refilled with distilled water and recharged with a Schumacker 10-amp, twin-rate battery charger. At first, batteries were recharged for only 3-4 hrs, after which time the battery tester indicated that they were fully charged. However, these batteries lasted for approximately only 2 days under constant draw-down in the field so charging time was increased to 12-24 hrs. There seemed to be no difference in battery life between batteries charged for 12 hrs versus 24 hrs (though this was not tested). The additional 12 hrs charging time made logistics of getting batteries back into the field difficult given the number of batteries available thus the 12-hr charge time was employed, thereafter. A 12-hr charge lasted for approximately 2 weeks under variable wet and freezing conditions.

We attempted to follow the protocol of Kucera et al. (1995) regarding the checking of cameras (first check after 2 days, then every 14 days), but encountered a variety of problems. To address these problems and have some assurance that bait stations were being monitored constantly we felt that it was necessary to check cameras more often. Subsequently, cameras were checked at 7-day intervals. When checking cameras, we walk-tested them on arrival to determine whether they were still monitoring a set. Notes were kept as to the condition of a site on arrival, the tracks present, and status of the camera. Three-volt lithium camera batteries were tested and changed if they fell below 3 volts. Adjustments were made to sensor fields as needed to insure that subjects would be within range before cameras were triggered. Film was changed when approximately ≥ half the roll had been exposed.

After slide or print film were developed, their contents were analyzed using a light table and hand lens. Negatives and slides were sheathed in labelled, plastic covers and placed in

ring-binders. Date, time, exposure and contents of slides were recorded for each roll of film on the "35-mm Camera Results" data form provided by Zielinski and Kucera (1995). This information was entered into a data base for summary and analysis in SPSS® (Norusis, 1990).

Comparison of latency to detection of marten between the first and second survey periods was made using the nonparametric Wilcoxon-Mann-Whitney test due to an inability to test assumptions of normality given the small sample size. Pair-wise comparisons were made between marten (*Martes americana*), red squirrel (*Tamiasciurus hudsonicus*), and snowshoe hare (*Lepus americanus*) activity at camera stations using t-tests. Analysis of variance was not used because the assumption of equal variance was not met. Approximate t-tests using separate variance estimates were used because they assume unequal variance (Norusis, 1990; Sokal and Rohlf, 1981). Furthermore, comparisons between martens and snowshoe hares, and martens and red squirrels employed 1-tailed tests based on the *a priori* assumption that the predators would be more active at baited camera stations than their prey. A 2-tailed test was used to compare hares and squirrels. P-values were not corrected for multiple tests. A pooled variance estimate t-test was used to determine the effect of trails on marten and human/domestic dog (*Canis familiaris*) visitation to camera stations. Data used in parametric tests required natural log transformations to meet assumptions of normality. One was added to each data set to avoid the undefined solution resulting from taking the natural log of 0.

RESULTS AND DISCUSSION

Three of the 4 target species were recorded during the remote-sensing camera survey: marten, fisher (*Martes pennanti*), and wolverine (*Gulo gulo*) (Table 1; Appendix 1). Marten were observed in all 8 sampling units (Figure 6). Mean latency to detection (LTD) was 13.5 ± 4.9 (SE) days for marten. Fisher were

photographed in Unit 2 in Bear Creek and in Unit 1 of Big Creek (Figure 7). Mean LTD was 9.0 ± 7.0 days. A wolverine was observed at both cameras in upper Sweathouse Creek drainage, Unit 2 (Figure 8). LTD was 13 days.

Estimates of LTD for marten differed dramatically between the first survey period (Bear Creek/Big Creek) where the mean LTD was 24.0 ± 6.3 days and the second survey period (Sweathouse Creek/Bass Creek) where the mean LTD was 3.0 ± 1.1 days (Wilcoxon-Mann-Whitney test; $P = 0.028$).

Two nontarget predators which were commonly observed in all drainages during snow tracking were the coyote (*Canis latrans*) and mountain lion (*Felis concolor*). Both were drawn to baited camera stations as indicated by tracks near stations, but both exhibited strong avoidance with regard to entering stations and triggering cameras. Coyotes were photographed only twice during the entire survey, but used trails almost daily in all canyons. Coyotes using trails as travel routes bypassed stations on trails by leaving the trail until they passed the camera stations. They also detoured from trails to approach camera stations placed off trails, but they avoided the sensor field even though they sometimes approached to within 5 m of the bait.

Mountain lions similarly avoided camera stations even though they could easily have reached many baits and pulled them down. Mountain lions were not as common as coyotes as indicated by snow tracking nor did they use trails to the extent that coyotes did. However, mountain lions were observed in all 4 drainages and did commonly use trails as travel routes. One mountain lion (possibly 2, see Appendix 2) was photographed at a camera station.

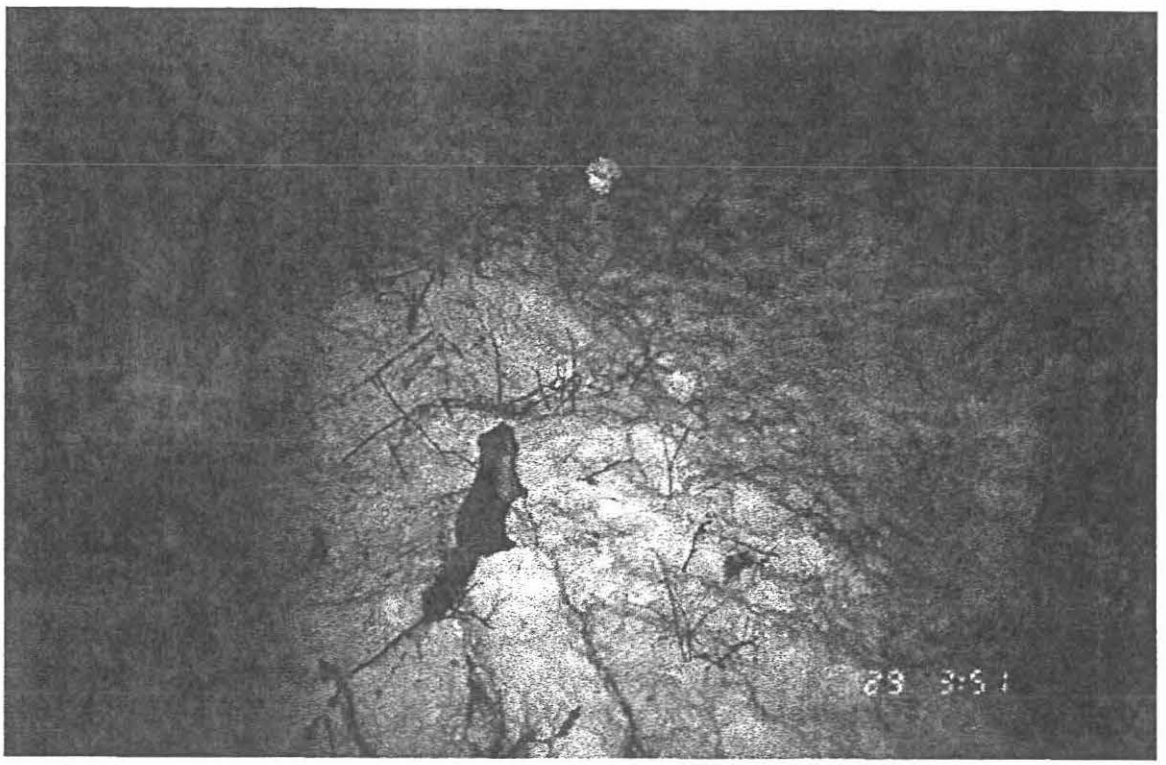
Due to down time resulting from camera malfunctions, battery problems, and cameras running out of film (Table 2; Appendix 3), an extra 18 days on average were required to achieve the minimum 30 day survey. This roughly translated to 1.6 units of effort for every unit return. Overall cameras were effectively monitoring bait stations 62% of the time that they were set out.

Table 1. Species of forest carnivores detected in 4 drainages on the Bitterroot National Forest using Manley remote-sensing cameras. The number of observations and latency to detection are given where a species was recorded. Latency to detection (LTD), the number of days to first detection of the target species, is given in parentheses. An observation is defined as an occurrence of a species (≥ 1 photograph) separated by > 1 hour.

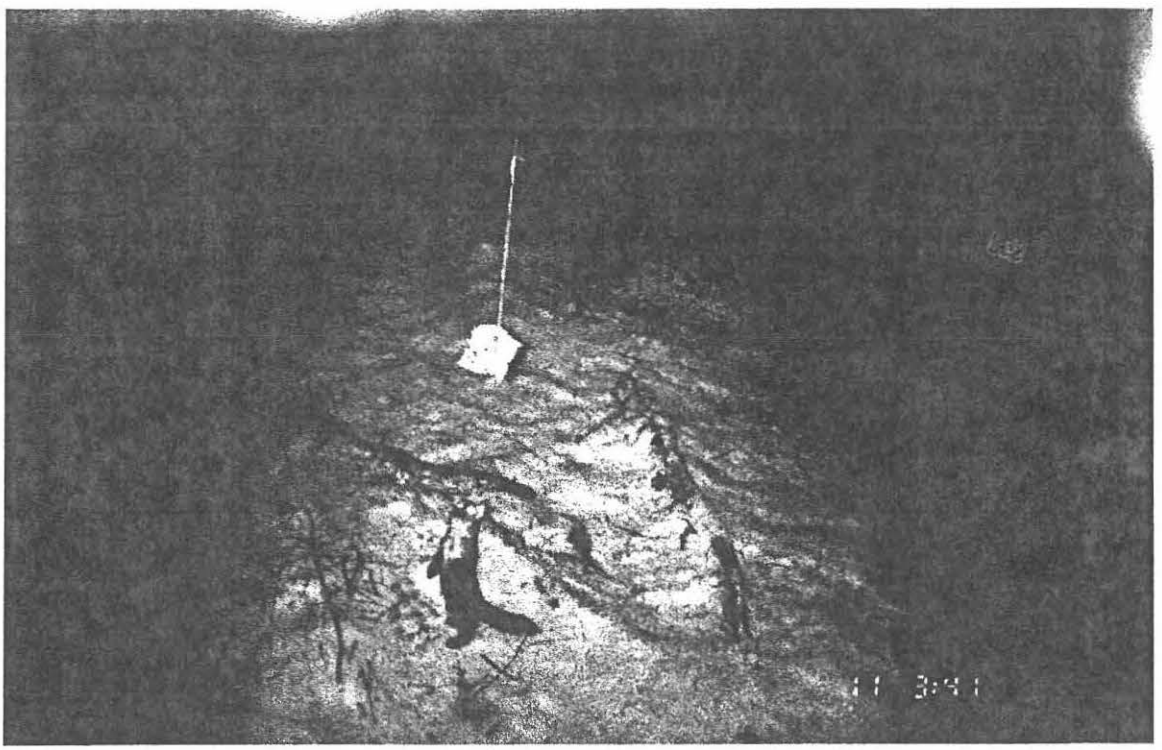
		Number of observations and latency to detection for target species			
Drainage	Unit	*Martes americana*	*Martes pennanti*	*Gulo gulo*	*Lynx lynx*
Bear Creek	1	3 (42)			
	2	4 (17)	1 (16)		
Sweathouse	1	19 (2)			
	2	14 (6)*		3 (13)	
Big Creek	1	13 (23)	3 (2)		
	2	18 (14)			
Bass Creek	1	11 (1)			
	2	3 (3)			
# observ.		85	4	3	0
x LTD		13.5	9		
SE LTD		4.9	7.0		

* Latency to detection for Sweathouse Creek Unit 2 was estimated based on sign left in snow because the cameras in this unit were not printing dates during the first week of the survey. This estimate is conservative. The site may have been visited a day earlier.

Three hundred of the 797 days that cameras were in the field, they were "down" (not monitoring bait stations). Six categories of camera system failure were identified. "Battery dead" included any malfunction of 3-volt lithium or 12-volt system batteries resulting from insufficient amperage to trigger full flashes or initiate film exposure. It was generally not possible to discern between the failure of the 2 battery types since they were often both dead when stations

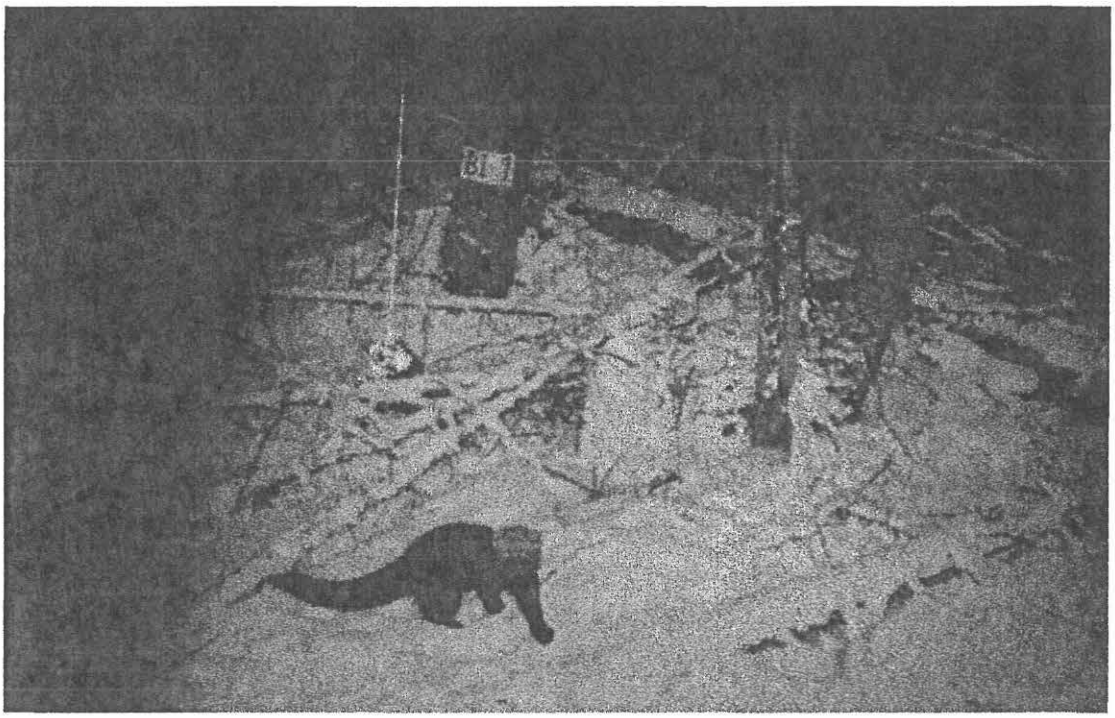


(A)



(B)

Figure 6. American martens documented from (A) Big Creek, and (B) Bear Creek drainages of Bitterroot National Forest.



(A)

(B)

Figure 7. Fisher documented from Big Creek, Bitterroot National Forest using (A) Manley dual sensor camera unit, and (B) Trailmaster unit.

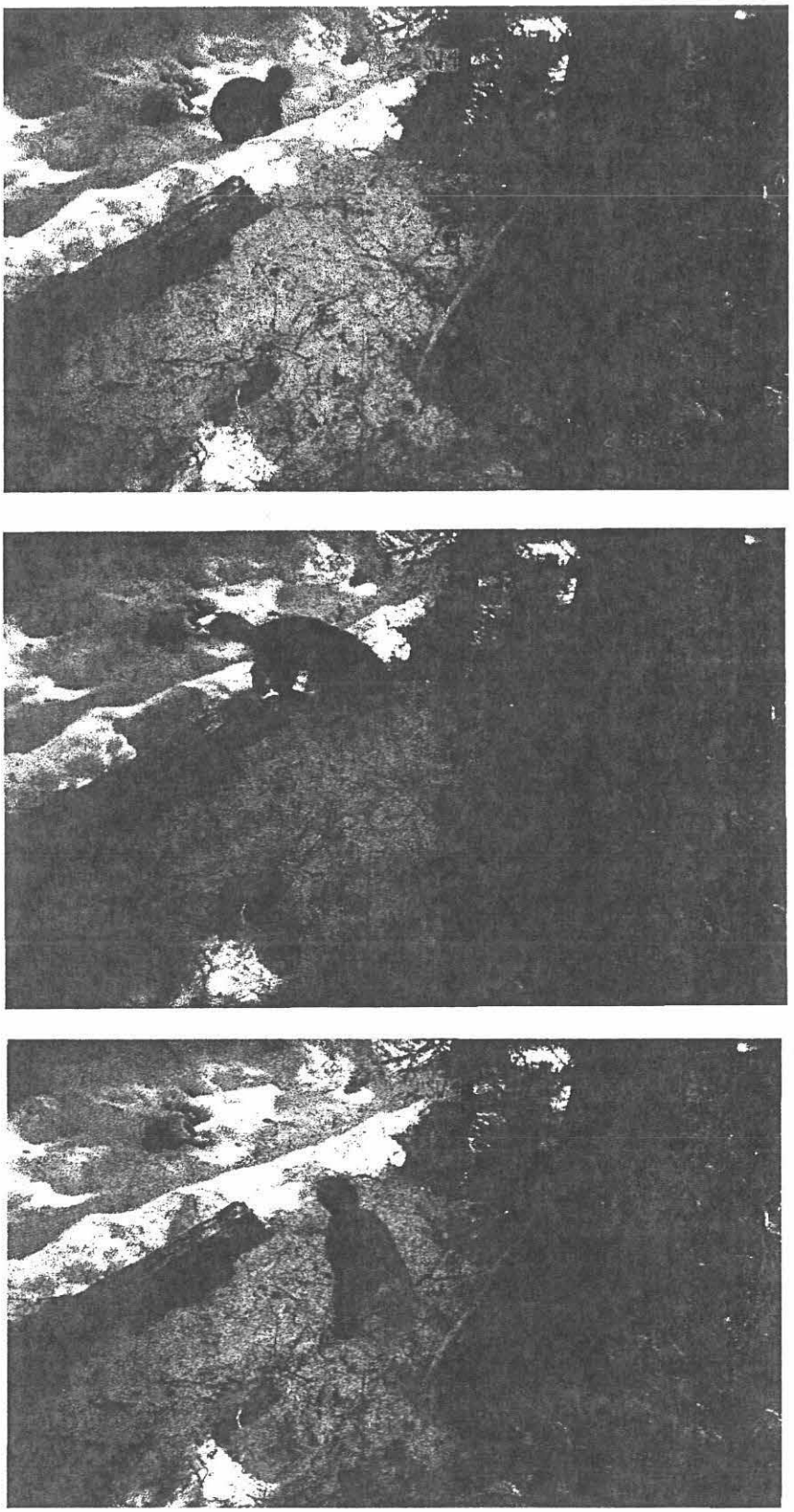


Figure 8. A wolverine documented in the upper portion of the Sweathouse Creek drainage of Bitterroot National Forest [February 2, 1995; 10:15 - 10:16 a.m.].

were checked. Electronic malfunctions occurred wherein the camera advanced and/or rewound the film automatically without being triggered or when triggered only once. These camera system failures were categorized as "Film advanced". "Film spent" resulted when all exposures were shot before the camera was rechecked (this did not include film advanced category). "Contact broke" was assigned to failures wherein the contact connecting sensor to camera broke. This happened on 2 cameras. "Shutter stuck" occurred when shutters locked open, apparently due to cold. "Hood fell" occurred when the camera hood fell blocking the lens. This happened only once, but affected an entire roll of film.

A breakdown of camera system down time indicated the importance of various causes for system failure: Battery dead (147 days/49%); Film advanced (59 days/20%); Film spent (39 days/13%); Contact broke (24 days/8%); Hood fell (15 days/5%); Shutter stuck (16 days/5%) (Figure 8). The first 3 of these accounted for 82% of the total down time. By far the single most significant cause of camera down time was battery failure (49%). Marten visitation did not differ among camera stations located on trails ($x = 4.9$ observations $\pm$ 1.5) versus off trails ($x = 4.6 \pm 1.8$) ($t = -0.74$, $df = 15.48$, $P = 0.473$). Limited observations of fisher (n=4) and wolverine (n=3) precluded a test of this hypothesis for these species. Fisher were observed twice at camera stations on trails and twice at camera stations off trails. All wolverines were observed at camera stations on trails. However, since cameras in the only unit where a wolverine was observed were both on the trail, this result is an artifact of the small sample size.

Visitation by people and domestic dogs was higher on trails($x = 1.75$ observations $\pm$ 0.49) than off trails ($x = 0.9 \pm 0.38$), though this was not statistically significant ($t = -1.38$, $df = 14.79$, $P = 0.184$). Lack of significance observed for use of trails by people and dogs was probably the result of small sample size and the resulting high variance. The number of observations

Table 2. Survey duration and actual monitoring time for each of 16 remote-sensing camera stations set out in 4 drainages of the Bitterroot National Forest. Cameras were left out as long as possible to achieve a minimum 30-day survey for each station. The total time each camera was in the field and the time the camera was actively monitoring a site are given in columns 4 and 5. The percentage of time that a camera actively monitored a bait station is given in the last column.

Drainage	Unit	Camera	Days out	Days active	Percentage Days active
Bear Creek	1	1	68	34	50
		2	56	40	71
	2	3	54	36	67
		4	52	26	50
Sweathouse	1	1	56	38	68
		2	22*	17	77
	2	3	45	24	53
		4	38	29	76
Big Creek	1	1	53	33	62
		2	54	40	74
	2	3	50	32	64
		4	63	44	70
Bass Creek	1	1	49	29	59
		2	57	18	32
	2	3	40	32	80
		4	40	25	63
Sum			797	497	
$\bar{x}$			49.8	31.1	64.00
SE			2.8	1.9	0.03

* This camera was stolen. The last roll of film collected ran until 02/22/95.

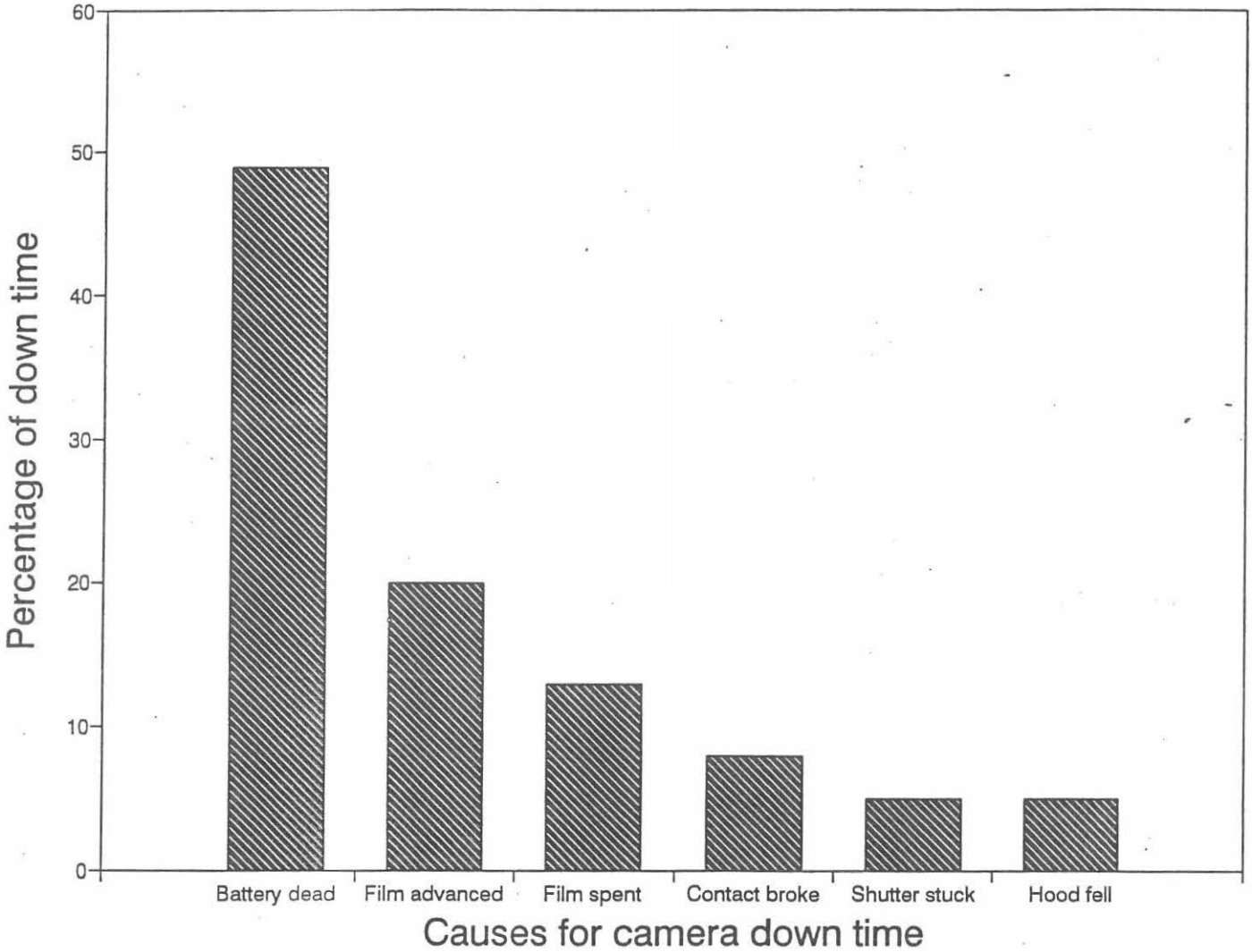


Figure 9. Causes for camera down time presented as percentage of total down time. **Battery dead:** any malfunction of 3-volt lithium or 12-volt system battery. **Film advanced:** electronic malfunction wherein the camera advances and/or rewinds the film automatically without being triggered or when triggered only once. **Film spent:** all exposures shot before camera rechecked (does not include film advanced category). **Contact broke:** contact connecting sensor to camera broke. **Shutter stuck:** shutter locked open apparently due to cold. **Hood fell:** only the hood was visible in photographs.

made at camera stations on trails were on average approximately double those made at stations off trails. The average number of exposures spent on people and dogs was significantly higher for camera stations on trails ($\bar{x}$ = 8.6 ± 3.2) than off trails ($\bar{x}$ = 1.5 ± 1.2) (t = -2.45, df = 16, P = 0.026), but did not differ for marten ($\bar{x}$ = 13.1 ± 4.4 vs. $\bar{x}$ = 14.8 ± 4.1 respectively) (t = 0.27, df = 16, P = 0.791).

Beyond the basic survey information obtainable using remote-sensing cameras, additional information was obtained regarding activity patterns of both predators and prey. An assessment of the degree of nocturnal activity was made for the 3 recorded target species and 2 commonly occurring prey species: marten, fisher, wolverine, snowshoe hare, and red squirrel (Table 3; Appendix 4). Seventy-three percent of 85 marten observations were made at night. We estimate that at least 10 and possibly more than 16 martens were involved in these visits. Fisher observations always occurred at night, but only 4 observations were made on, we believe, 2 fishers. However, while testing Trailmaster® and Manley cameras in the Spring, 7 more observations made on 1 additional fisher were also entirely nocturnal. Three observations made on what was likely a single wolverine were all diurnal. Snowshoe hares triggered cameras for 25 observations all of which were nocturnal. Twenty-two observations of red squirrels were obtained, 86% percent of which were diurnal. The 14% of red squirrel observations which were classified as nocturnal were all made at dawn or dusk, during periods of low light, but not total darkness.

Non-target species such as snowshoe hares and red squirrels triggered cameras on average < 1.5 times per observation (Table 3) (Figure 10). Predators drawn into the baits triggered cameras from 2.3 to 4.3 times per observation, depending on species (and sample size). Differences between predators were not statistically tested due to small sample sizes for fisher (n=4) and wolverine (n=3), but means and standard errors in Table 3

Table 3. Behavioral information for forest carnivores and prey species obtained from remote-sensing cameras in 4 drainages on the Bitterroot National Forest. The second column gives the percentage of visits which occurred during hours of darkness for each species. The third column gives the average number of exposures per observation, an indication of how active animals were at the baits. The total number of observations for each species is given in the fourth column.

Species	% of observations which were nocturnal	$\bar{x}$ # exposures/ observ. ± SE	Total # observ.
Martes americana	73%	2.9 ± 0.31	85
Martes pennanti	100%	4.3 ± 1.97	4
Gulo gulo	0%	2.3 ± 0.88	3
Lepus americanus	100%	1.2 ± 0.09	25
Tamiasciurus hudsonicus	14%	1.4 ± 0.23	22

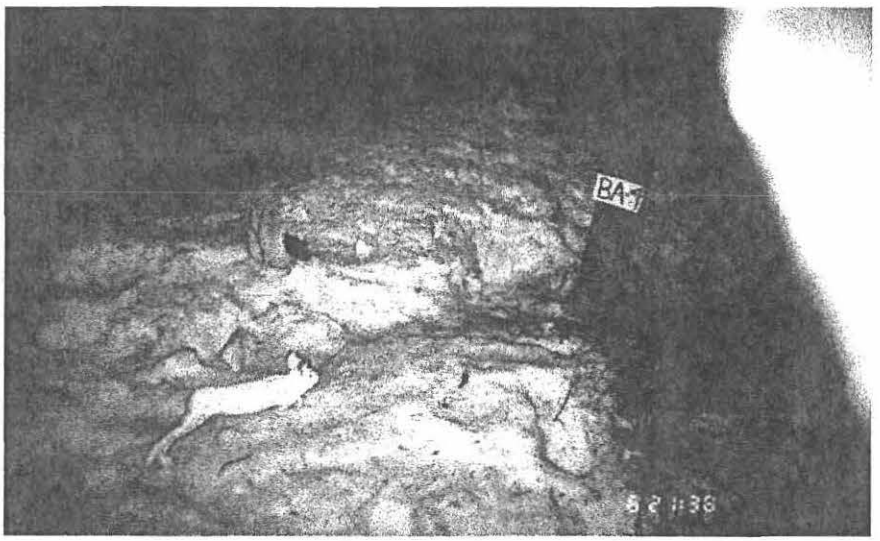
indicate high overlap between their distributions. Martens were significantly more active at baited camera stations than snowshoe hares ($t = 5.96$, $df = 106.76$, $P < .001$) or red squirrels ($t = 4.3$, $df = 61.12$, $P < .001$) indicating that occurrence of prey at camera stations was incidental. There was no difference in activity at camera stations between snowshoe hares and red squirrels as measured by the number of exposures per observation ($t = -0.46$, $df = 33.3$, $P = .648$).

CONCLUSIONS AND RECOMMENDATIONS

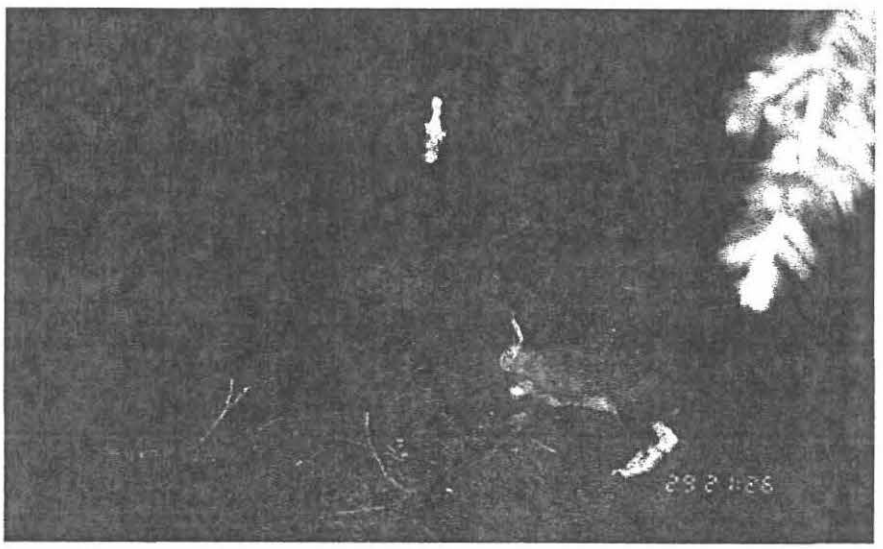
Several remote sensing camera systems have been utilized in surveys of forest carnivores (Kucera et al., 1995; Kucera and Barret, 1993; Jones and Raphael, 1993). All have successfully identified forest carnivores, but all have limitations for long-term winter surveys.

The Manley camera has been successfully employed in a variety of field conditions (T. Manley, pers. comm.), but it has

(A)



(B)



(C)

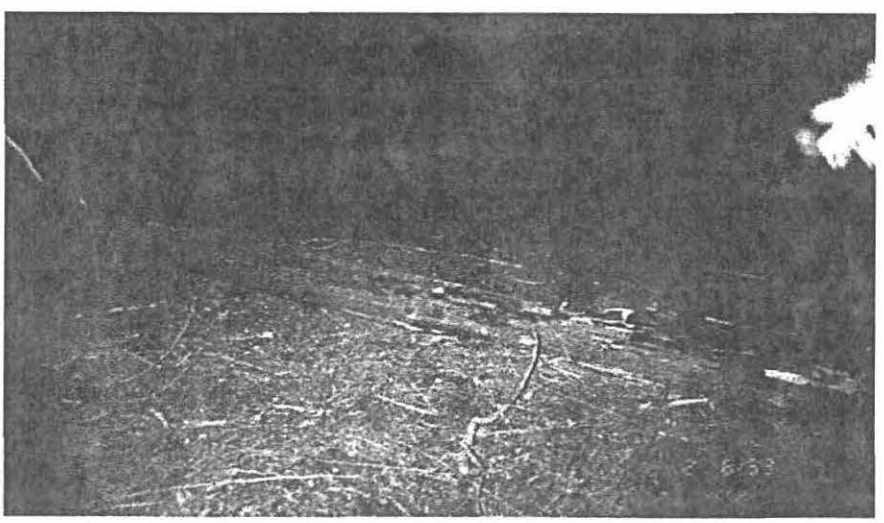


Figure 10. Two common prey species (A & B): snowshoe hare in winter and summer pelage, respectively, and (C)red squirrel, routinely recorded in Bitterroot National Forest.

not been field tested for long periods in the winter. It is apparent from the current study that MCS's do have the potential to successfully survey forest carnivores. However, numerous modifications must be made in the survey protocol of Kucera et al. (1995) to effectively employ this camera, and possibly other camera types, for 30-day winter surveys targeting forest carnivores.

Latency to detection:

Several hypotheses could be offered to explain the significantly later detection times for marten during the first survey period of this study: 1) martens had visited camera sets, but were not recorded due to camera malfunction; 2) martens avoided sets; 3) snow conditions restricted marten movements during this period. The first hypothesis is quickly ruled out because deep snow provided an excellent medium for assessing activities at camera stations for the first 2 to 3 weeks of the survey. No marten tracks were observed at any stations during this time. The second hypothesis seems unlikely given the short LTD's for Sweathouse Creek and Bass Creek, $\bar{x} = 3.0 \pm 1.1$ days. These LTD's compare well with those given by Zielinski et al. (in prep. as cited in Kucera et al., 1995) who reviewed tracking plate and camera studies to estimate LTD times for marten. LTD's of 3.7 for the large composite sample of Zielinski et al. and 3.0 for Sweathouse Creek and Bass Creek suggest it is improbable that martens would avoid heavily baited and scented sets for an average of 24 days.

Although Raine (1983) suggested that marten were less affected by snow conditions in southeastern Manitoba than were fisher he indicated that snow conditions had some affect on marten mobility. Krohn et al. (1995) have also shown that snow conditions affect fisher habitat use. Initial snows in the current study were sufficiently deep (3-4 dm) to impede marten movements (Raine, 1983), and the soft powdery conditions may have confined marten activities to areas of shallower snow because of

its inability to support their weight. Marten tracks were rare along trails during this period. A fisher which was tracked at this time was forced to travel through drifts of powdery snow over 6 dm deep, sinking on each bound. Marten would have sunk nearly as deep, and with their shorter limbs would have burned more energy than the fisher in moving through the snow. The first crust developed in late December after warming and freezing altered the snow surface. Soon after, martens were recorded at camera stations and tracks were commonly observed along trails; martens stayed on top of the crust once it developed.

Camera placement:

Three primary factors affect the decision of camera placement: 1) optimizing likelihood of observing the target species; 2) accessibility for research purposes; 3) minimizing chances of disturbance, vandalism, or theft. Optimizing the likelihood of observing the target species is the first priority. However, this goal is offset by both accessibility of cameras for research and disturbance of cameras.

Initial observations of tracks suggested that trails might be favored as travel corridors by marten and fisher. Raine's (1983) snow tracking data for marten and fisher indicated that both species used previously established trails to facilitate winter travel also suggesting that trails might provide optimal sights for camera stations.

Cables and padlocks secured cameras to trees and locked the camera systems closed. Cameras were bolted to trees 2-3 m above the ground. Nevertheless, one camera was stolen. Cameras on or visible from trails received greater human visitation than cameras placed off trails and out of view of passersby, even when off-trail camera were only a short distance off trails. However, marten were not affected by the presence or absence of trails at bait stations. Hiding cameras off trails seems to be more effective at deterring human disturbance than the use of locks or raising cameras, and does not significantly reduce visitation by

marten. Though this could not be tested for other target species, we expect the same is true.

Kucera et al. (1995) recommend placing MCS's in a tree 3-4 m above the ground to discourage disturbance by people and animals. However, placing cameras 3 m above the ground limits the effective distance of the flash to 1.1 m from the base of the tree. Since 4 m exceeds the effective flash distance of the Yashika AW-mini™ camera using 100 ASA film, theoretical flash distance does not even reach the base of a tree when cameras are mounted 4 m from the ground. Although increasing the ASA increases flash distance, as does the presence of snow (from its reflective properties), it is apparent that the higher a camera is placed in a tree the more limited will be the field of view. Since most observations of target species occurred at night (72% overall; 73% for marten; 100% for fisher; 0% for wolverine [Table 3]), we recommend camera sets be configured based on the limitations incurred by nocturnal visitation.

Humans may best be deterred by hiding cameras, and black bears (*Ursus americanus*) are generally not a problem in winter. Therefore, we recommend that camera heights range between 1-2 m in winter as well as at other times when bears are not deemed a great threat to the equipment. Placement approximately 1.2-1.5 m high is optimal for identifying subjects and maximizing effective flash distances and camera viewing fields. At 2 m in elevation an effective flash distance of 2.5 meters from the tree base is attained (with 100 ASA film and no snow). Cameras hidden near trails should be placed where fishermen, hikers, or recreationalists are unlikely to go, and trails made checking cameras should remain obscure. Cameras should be camouflage painted and covered from the back and sides with evergreen bows and/or bark. Cameras employed in high use areas where human activity increases the likelihood of discovery, should be placed higher in trees, camouflaged, and locked.

Intervals for checking camera stations:

Kucera et al. (1995) recommend that 35-mm systems be checked 2 days after initial set up and 2 more times at bi-weekly intervals up to 30 days or until target species are observed. We advise that cameras be checked once weekly for 28 days and the initial 2-day check be ignored. If deemed necessary, the 2 additional days can be included by increasing 2 of the 4 intervals to 8 days. However, since the 30-day survey period is already subjective, we feel, for reasons stated below, that 28 days is a more appropriate alternative. Cameras functioning properly when initially set, seldom failed in the first 2 days, but film often ran out before 2 weeks were up due to high marten, fisher, moose, and human activity or because of camera failure due to automatic film advancement. Checking cameras at 2-week intervals therefore was insufficient to insure they were actively monitoring bait stations. Furthermore, longer intervals meant cameras would be down for longer periods if camera failure occurred, decreasing active monitoring time and increasing the likelihood that a critical visitation would go unobserved.

The suggested 7-day interval would appear to be convenient for wildlife biologists conducting camera surveys while committed to other duties. Under this regime, 1 day each week could be assigned to the checking of a survey route. In this manner cameras would be checked on the same day each week and the rotation would not require checking cameras on weekends. We feel that stations should be checked early in the week (Monday is best) because increased weekend activities by recreationalists may result in exposure of film or disturbance of stations. Checks early in the week would insure cameras are functioning properly during the period when human activity is lowest.

Sensor range and restricting the sensor field:

Two magnets are provided with each MCS to delimit the sensor field. We attempted to match the sensor field to that of the viewing field in order to maximize the monitoring area, but this

inevitably resulted in some animals triggering cameras before they entered the viewing field. The sensor field should remain well within the viewing field to safeguard against cameras triggering prematurely and spooking the subject before it enters the viewing field. A third magnet should be attached to restrict the top of the sensor field, thereby limiting the distance that the sensor can detect subjects in the forward direction. This is especially important when placing the camera on a trail or path where the subject will likely approach from the front. However, limiting sensor fields should be balanced against overly restricting the field. In our study wolverine appeared tentative when approaching stations and may not approach baits closely enough to trigger sets if the sensor field is too specific. The same may be true for lynx given the timidity of the mountain lions which approached, but avoided, our camera stations.

Yashika™ camera specifications indicate the Yashika AW-mini™ focuses from 0.95 to ∞ m in daylight and that the flash is effective from 0.95 to 3.2 m (3.1 - 10.5 ft.) with 100 ASA film. We did not quantify the effective distance of cameras at night. However, it was apparent that good snow cover greatly enhanced the effect of the flash at night due to its high reflectivity. Effective flash distance may be increased by nearly a meter as compared with non-snow periods when dark colored backgrounds such as bare ground and dark vegetation consume light from the flash.

Batteries:

Two types of lead-acid batteries were used in the MCS in this study to operate the sensors: a small maintenance-free 12-volt battery and a larger low maintenance tractor or lawnmower-type 12-volt battery. The obvious advantage of the smaller battery is that it weighs approximately half that of the larger battery (7 vs. 15 pounds). It also does not require refilling with distilled water and it does not leak battery acid. However, it lasts only about 7 days under winter field conditions with constant draw-down. The larger, heavier 12-volt battery leaks

battery acid and requires occasional refilling with distilled water, but it lasts approximately 14 days with constant draw-down under winter field conditions. Since neither of the batteries tested lasted for 30 days in the field, batteries must be recharged (at least once using the larger batteries and 3 times using the smaller batteries) during a 30-day survey. Logistically, this limitation necessitates that extra batteries be available in order to rotate them without having down time at camera stations for recharging.

Larger, deep-cell 12-volt batteries used in cars may last longer in the field. However, these are more expensive, much heavier, and still may not last the full 30 days. Furthermore, due to their weight, these larger batteries could only be used when camera stations are very close to roads or other predictable motorized access routes.

Three-volt lithium batteries were used in all cameras to operate the flash units and advance the film. Small plastic inserts, supplied by the manufacturer, were used to adapt the Yashika™ cameras to 3-volt batteries. Discussions with Tim Manley and operators of photo labs indicated that 3-volt lithium batteries survive the longest of any camera batteries on the market under cold conditions and constant draw-down. Kucera et al. (1995) suggest that 3-volt lithium batteries are good for 20 rolls of 36-exposure film, assuming that the flash operates on half the exposures, but that under constant draw-down they may last only 4-8 weeks. We found that given partial canopy cover, overcast winter conditions, and the high nocturnal visitation observed by most species, flashes were used more than 50% of the time. Furthermore, under constant draw-down during our winter surveys, 3-volt batteries only lasted approximately 1 week. Once they fell below 2.8 volts, the flash was ineffective and the battery died completely soon after.

This is an important consideration in terms of costs. Three-volt lithium batteries are relatively expensive (ca. $7.00 - $10.00 each). Four lithium batteries per camera over a 30-day

survey can run from $28.00-$40.00. This range in cost also indicates the importance in locating generic brands and competitive outlets for 3-volt batteries.

We found that both 3-volt lithium and 12-volt batteries registering fully charged can drop below functioning capacity within 24 hrs. Therefore, *a priori* knowledge of battery life is extremely important to maximize monitoring effort in the field. Three-volt lithium batteries should be replaced at least once a week under winter conditions or once they drop below 2.9 volts if stations are checked more often than once per week. Twelve-volt system batteries should be charged at least 12 hrs using a slow- to moderate-rate battery charger. Twelve-volt batteries should be changed at least every 14 days or sooner if testing indicates the battery has fallen below 12 volts. If the smaller enclosed 12-volt battery is used, which we highly recommend, it should be replaced with a recharged battery every 7 days.

Because MCS's have no time delay control between exposures, several exposures can be taken in a minute (up to 8), and camera batteries do not have time to recharge completely resulting in poor illumination of the flash and, ultimately, black exposures when the flash does not respond at night. Although this malfunction accounts for a relatively small percentage of the observed camera failures, it can result in failure to identify the subject.

Walk test and field notes:

Walk testing is extremely important not only to initialize cameras before leaving, but also to determine their status when returning to check camera stations. Good field notes are critical. Snow and other sign should be studied when approaching camera stations, especially if the walk test indicates the camera is not functioning. Martens often defecate beneath the bait, and on some occasions, when a camera was down and the snow was illegible, this was the only indication that a target species had been present. Subjects which trigger cameras at the edge of the

flash's illumination, can be impossible to identify to species. At such times, notes taken on tracks observed at stations are critical to film interpretation. If tracks of target species are observed, measurements should be taken in case the subject was not photographed and as supplemental information for snow tracking data bases. Measurements from tracks of target species which are photographically confirmed are valuable assets to snow tracking data bases. Notes should also be carefully kept as to when the camera batteries and film were changed.

Other problems encountered:

Down time due to shutters sticking and contacts breaking was reduced by switching faulty cameras with spare cameras. Shutters could often be freed by solidly striking the top or bottom of the camera with an open hand. However, this was not always successful. Where spare cameras are not available, these factors could contribute more significantly to down time. It is best to send faulty cameras back to the manufacturer if simple maneuvers do not rectify the problem.

SECTION 2: TRACKING STATION SURVEY

METHODS

Six tracking stations were set in each 1-mile sample unit so that 3 open tracking stations were alternated with 3 closed tracking stations in a checkerboard arrangement (Figures 11-14). Stations were placed ca. 1/3 miles apart from west to east and as far apart from north to south as canyon width would allow up to ca. 1/3 mile. Stations straddled creeks so that sets on opposite sides of a creek were roughly paired on a north-south line. All tracking stations were scented with commercial trapping lures and baited with a chicken wing or leg. Feathers and a bag of catnip were hung at stations with open tracking plates to attract lynx. Surveys were conducted for at least 12 days. Stations were checked every other day and were rescented on the 2nd and 4th visits corresponding to the 4th and 8th days (2nd and 3rd quarters of the survey) since the tracking plates were set. Chicken was replaced periodically as needed in Bear Creek and Big Creek drainages, but was replaced on every visit in Bass Creek and Sweathouse Creek drainages due to heat and insects drying out and soiling bait.

Tracking plate surfaces were carboned on-site using a portable acetylene Victor® Performer welding torch denied of oxygen to enhance carbon output. Open tracking stations consisted of 2 sheets of 1/16" x 16" x 28" aluminum plates placed side by side on a leveled substrate to create a 32" x 28" tracking surface (Figure 15) (Zielinski, 1995). Bait was placed in the center of the plates after they were blackened with carbon. A feather and bag of catnip were hung separately within 5 m of open tracking stations.

Closed tracking plates were fashioned after the half-cylinder design outlined by Zielinski (1995) with a few modifications described here (Figure 16). A 1/16" x 8" x 30" sheet of aluminum flat stock was used for the tracking plate. A

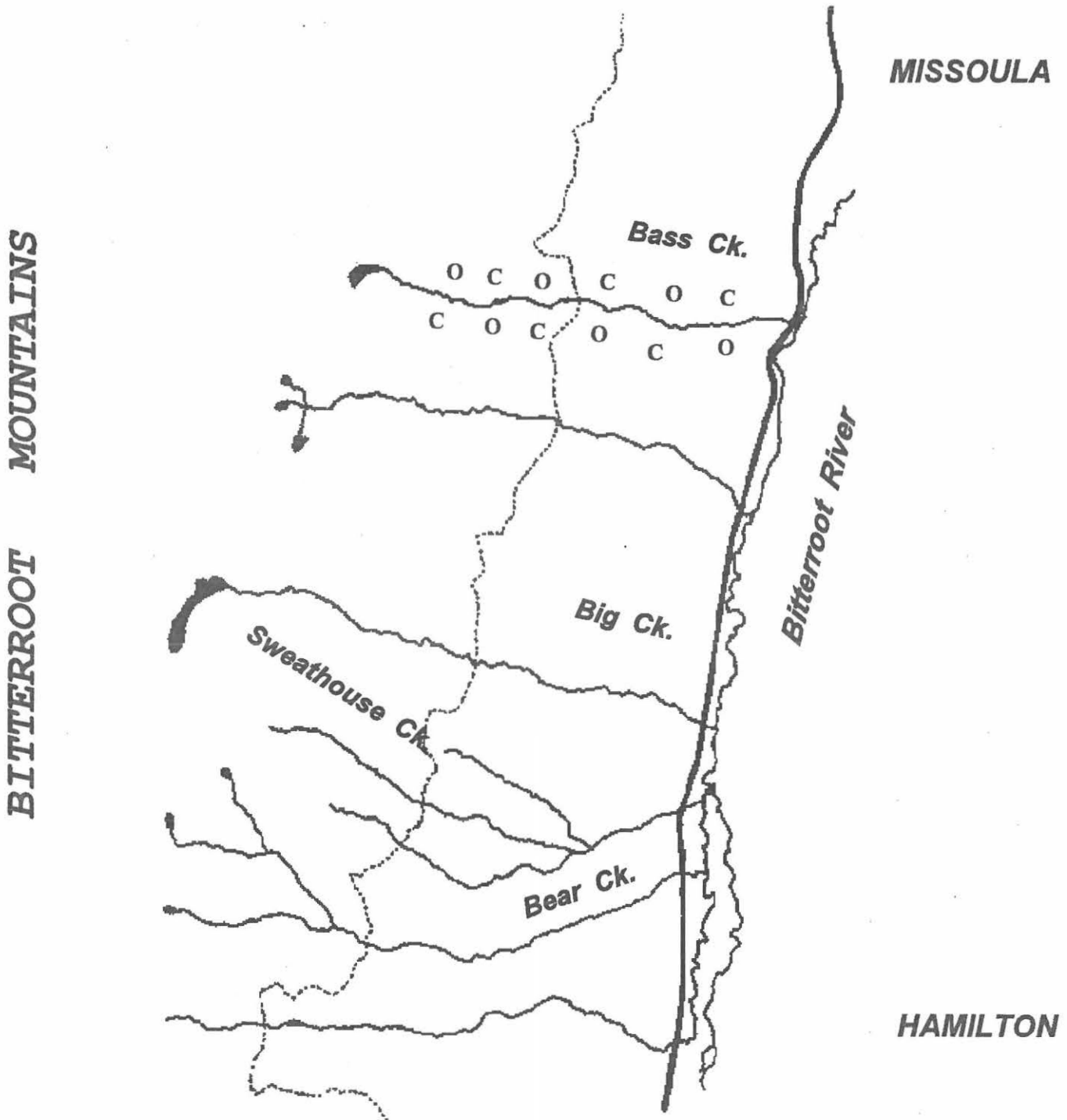


Figure 11. Placement of open and closed tracking plates in Bass Creek drainage. O = open stations, C = closed stations.

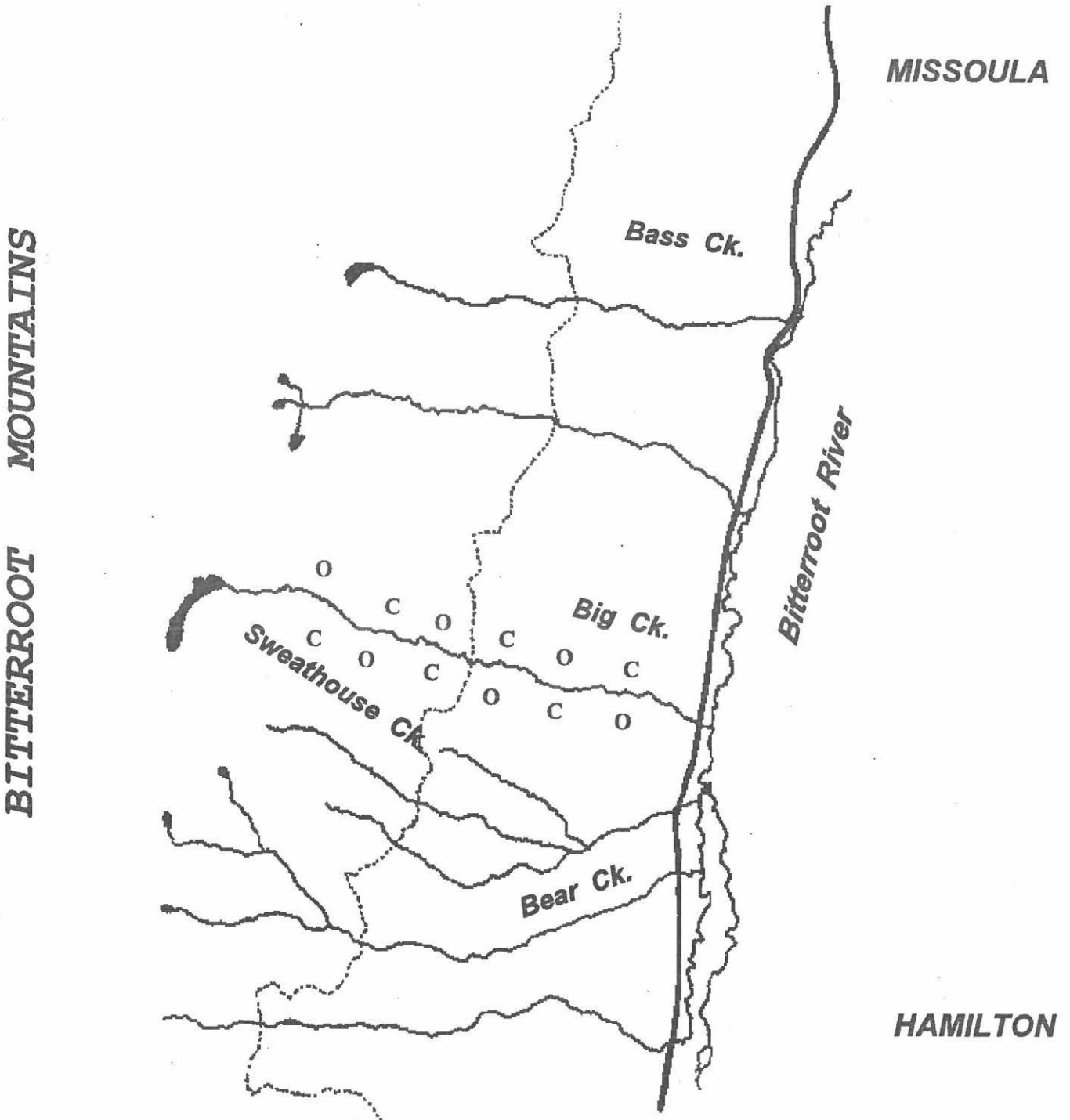


Figure 12. Placement of open and closed tracking plates in Big Creek drainage. O = open stations, C = closed stations.

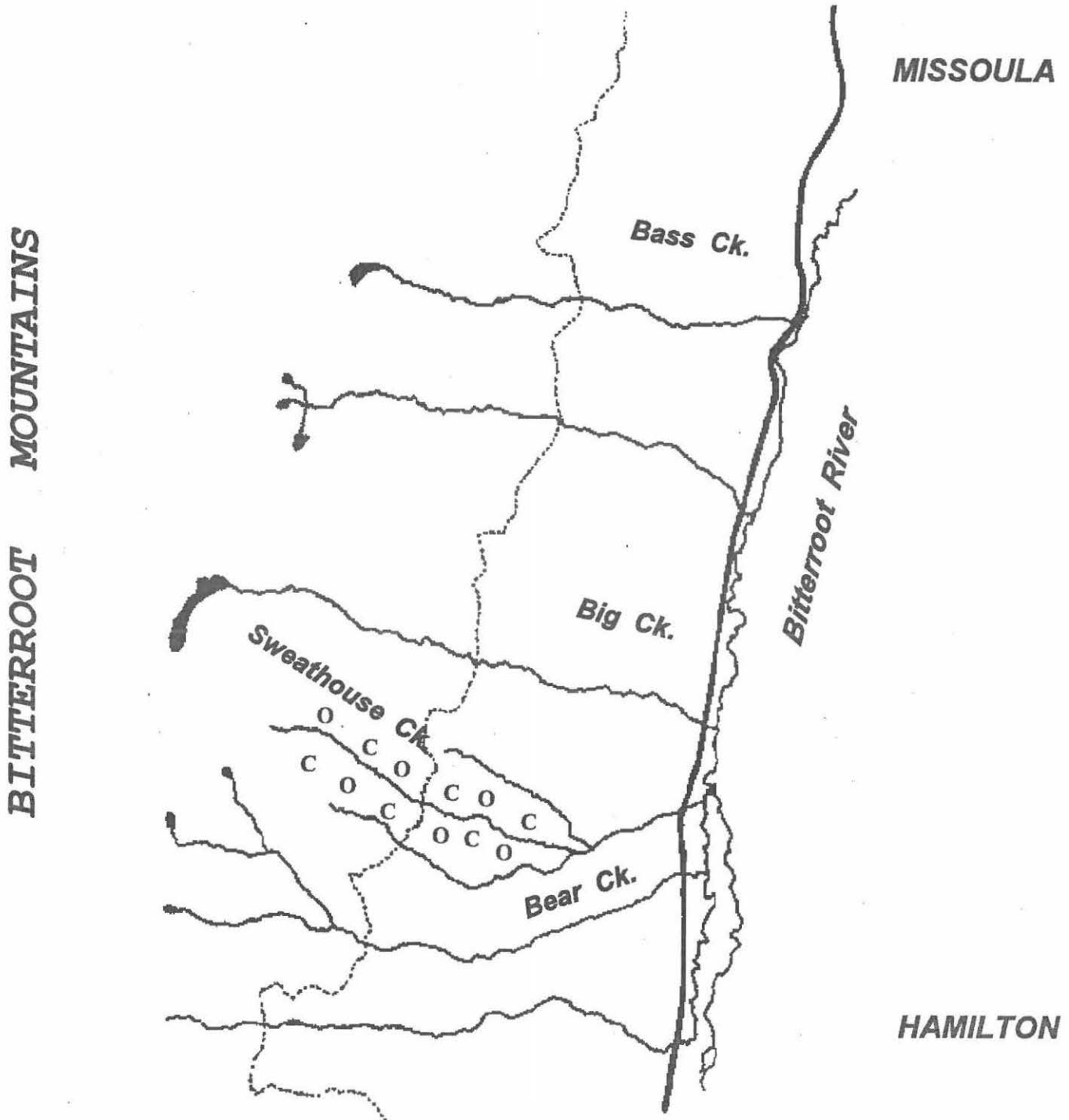


Figure 13. Placement of open and closed tracking plates in Sweathouse Creek drainage. O = open stations, C = closed stations.

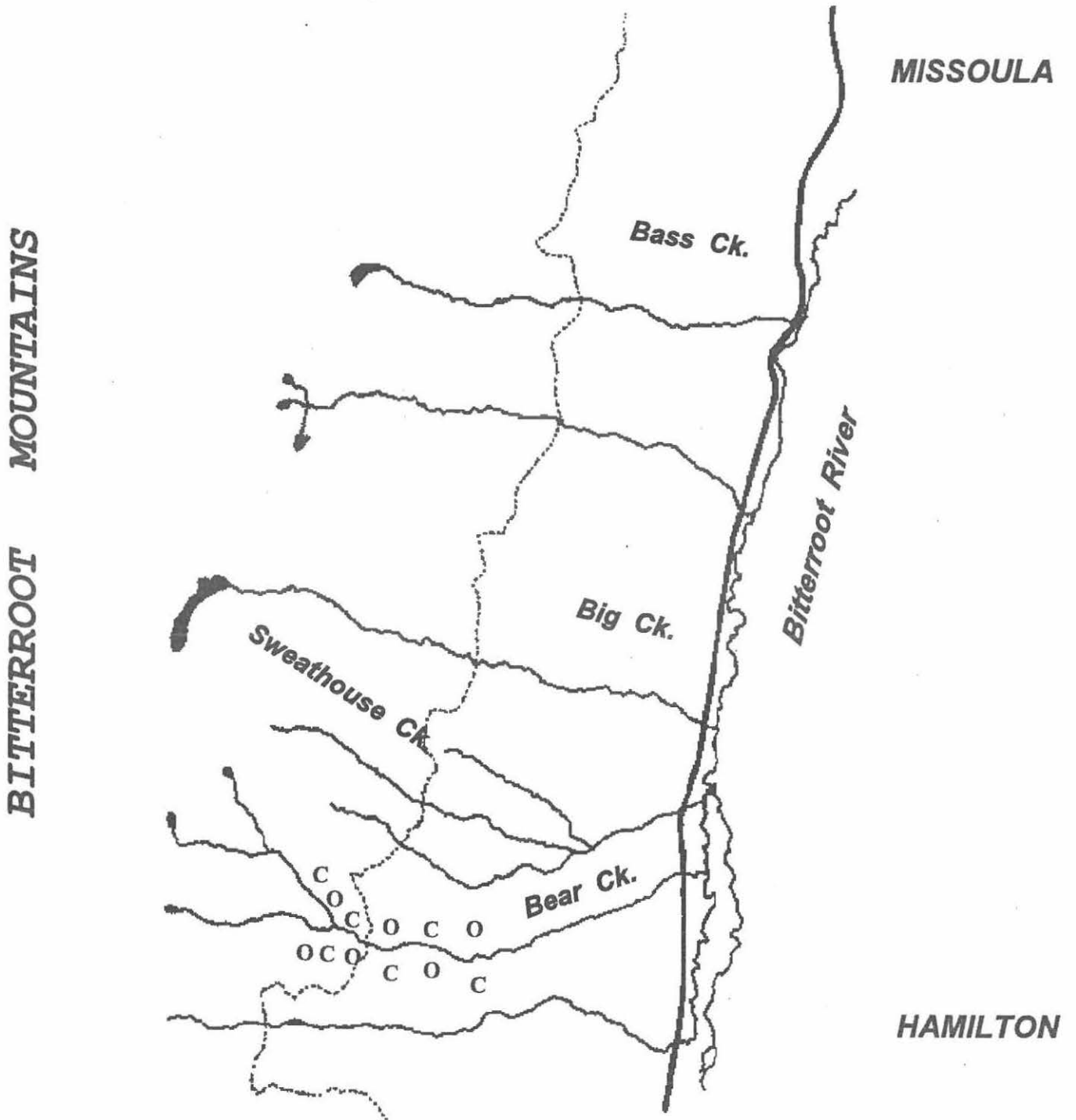


Figure 14. Placement of open and closed tracking plates in Bear Creek drainage. O = open stations, C = closed stations.

Figure 15. Open tracking station.

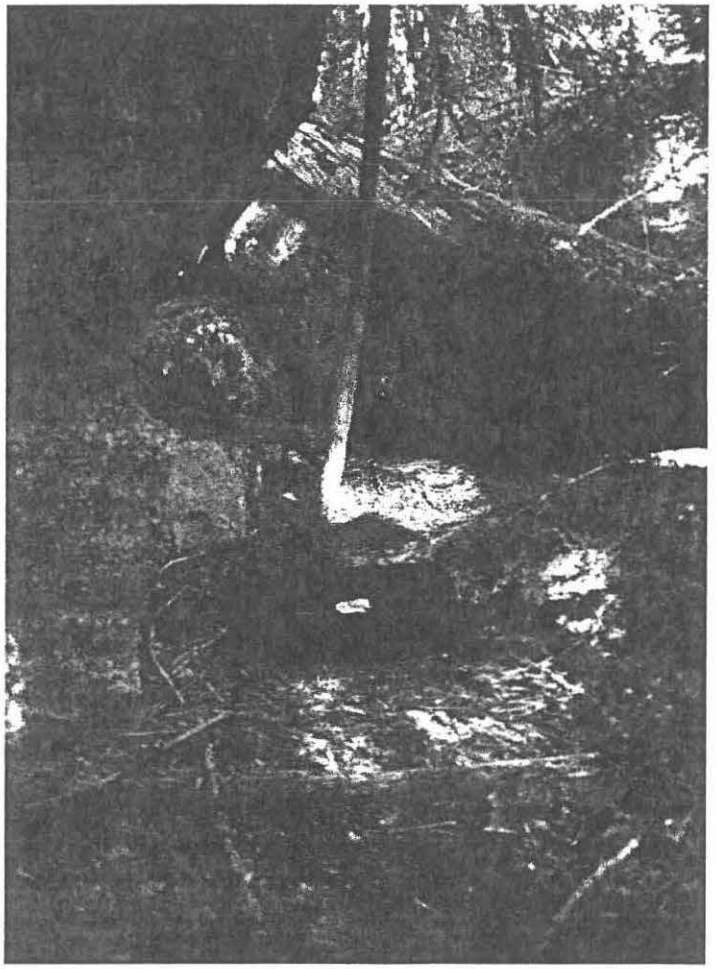


Figure 16. Closed tracking station.

base was constructed of 1/32" x 12" x 30" galvanized steel flat stock with the long edges (30" sides) bent up 1/2" at a 90 degree angle to form a lip. A plastic hood was made from 2 sheets of 1/8" x 16" x 28" PVC flat stock folded side by side over the galvanized steel base so that the edges tucked inside the lips of the base. A 2-inch overlap resulted from the hood dimensions. We recommend the overlap be shifted to the front of the galvanized steel base rather than centered over it. This provides a 2-inch awning to shelter the tracking plate from rain on the open side. Thinner plastic is preferable if it can be obtained. Zielinski (1995) recommends 1/16" PVC flat stock. However, we were unable to obtain the 1/16" material. We found the 1/8" PVC works well, but adds unnecessary weight. Four holes were drilled into each lip and through the PVC at corresponding locations so that sheet-metal screws could be used to secure the hood in place. Duct tape was used to cover the seam between the 2 sheets of plastic and to seal the seams created by the intersection of the plastic with the galvanized steel.

The above materials were transported to survey locations in a backpack and assembled on site. The resulting half-cylinder box was placed on a flat surface against a log and gaps at the back of the box were filled with branches and other debris. Rocks and debris were wedged against the sides to secure the box and used as camouflage to prevent human disturbance. A sheet of white contact paper (9" x 12") was placed over the tracking plate 4" from the back of the plate. The edges of the contact paper were peeled back so that it could be taped to the under-side of the tracking plate. After this was done, the forward section of plate was blackened with the torch and the sheet covering the contact paper was peeled off. The bait was placed behind the contact paper on the unblackened portion of the plate and the plate was slid into the half-cylinder box. Closed stations were scented using the same lures as open stations.

Surfaces of open tracking plates were regularly disturbed by debris and nontarget species. This disturbance necessitated

recarboning open plates on almost every visit. Old carbon and debris were wiped from plates before recarboning to provide a clean surface for prints. Foreprints of target species were collected from open plates by carefully pressing a 6 to 8-inch length of clear, wide adhesive tape to the plate over a well-defined print. By carefully running the tape roll back and forth over the tape and print, and leaving the ends of the tape free of carbon, a clear copy of the print could be removed from the tracking plate and affixed to a white piece of paper where it was labeled as to location, date, foot and suspected species. Foreprints were best identified by the presence of a metacarpal or heel pad not present on hindprints (Zielinski and Truex, 1995). However, the metacarpal pad is not always visible and marten tend to wander all over open plates making identification of foreprints difficult due to overlap of tracks and lack of a distinctive trail or gait pattern to identify individual feet. Prints of target species were not collected from open plates when they were excessively distorted or could not be identified as foreprints.

Closed tracking plates were recarboned when carbon on the aluminum plate was deemed insufficient to leave a clear print on the contact paper. When the contact paper was excessively marred by debris or tracks of nontarget species, the contact paper was changed. Contact sheets with prints of target species were collected from closed tracking plates by cutting away the folded edges and spraying the surface with Krylon Workable Fixatif Spray Coating to protect the print from smudging. After air-drying the spray coating for about 15 minutes, contact sheets were labeled and slipped into a field notebook between sheets of blank white paper for transportation. Contact sheets were removed from the notebook at the end of the day and allowed to dry for 24 h before being placed in clear polypropylene protectors. Contact sheets left in contact with dividing sheets too long, adhered to the paper and were difficult to remove without destroying the print.

Nine measurements were made on each set of tracks: length of

track from the anterior-most point of the anterior-most digit (3 or 4) to the posterior-most point of the metacarpal pad (L1); length of track from the anterior-most point of the anterior-most digit to the posterior-most point on interdigital pad number 1 (L2); length of track from the anterior-most point of the anterior-most digit to the posterior-most point on interdigital pad number 4 (L3); length of track from the anterior-most point of the anterior-most digit to the posterior-most point on interdigital pad number 3 (L4); width of track from the lateral-most to the medial-most point (when all 5 digits register) (W1); width of track from the lateral-most to the medial-most point (when digit 1 does not register) (W2); width of interdigital pad number 3 (WI3); length of interdigital pad number 3 (LI3); length of interdigital pad number 4 (LI4). All measurements were obtained by superimposing a Cartesian grid over the track and taking measurements along north-south and east-west vectors within the established grid as described by Zielinski and Truex (1995). Measurements were made on original tracks while in polypropylene covers rather than on photocopies of tracks as recommended by Zielinski and Truex (1995) because it was often difficult to determine print boundaries due to an animal shifting its position and weight. Original prints maintained subtle details of shade, texture and shape that allowed more accurate determination of print boundaries. A fine-tipped non-permanent marker was used to draw the grid directly on the polypropylene covers. Measurements were made to the nearest 0.01 mm using digital electronic calipers under a dissecting scope.

The measurements WI3, LI4 and LI3 were taken to distinguish between fisher and marten using the discriminant function classification algorithm developed by Zielinski and Truex (1995) which assigns tracks to fisher where $(4.595 \times WI3) + (3.146 \times LI3) + (0.906 \times LI4) - 80.285 > 0$ and to pine marten where the result is < 0. This algorithm was developed from positives of prints taken from contact paper, but we applied the same algorithm to negatives of tracks taken from open tracking plates

based on the assumption that inside measurements taken from negatives were equivalent to outside measurements taken from positive contact prints. All prints showing sufficient detail to provide the necessary measurements to apply the classification algorithm were used.

RESULTS AND DISCUSSION

Tracking-plate surveys ran from 4/24/95 to 6/05/95 for the 4 drainages surveyed on Bitterroot National Forest. Bear Creek and Big Creek drainages were surveyed concurrently from 4/24/95 to 5/09/95 and Bass Creek and Sweathouse Creek drainages were surveyed from 05/21/95 to 06/05/95. During the Bear Creek/Big Creek survey there was no 2-day interval without precipitation. As a result, open tracking plates were rendered essentially nonfunctional throughout this period because carbon was washed from the plates. Rain was more intermittent during the survey of Sweathouse Creek and Bass Creek allowing a comparison between open and closed tracking plates.

Of the 4 species targeted, only fisher and marten were identified using tracking plates. Fisher were located in 3 of the 8 units (38%) surveyed and marten were recorded in 6 of the 8 units (75%) (Table 4; Appendix 5). Fisher were identified in Units 1 and 2 of Bear Creek and Unit 2 of Big Creek (Figure 17). Marten were recorded in Units 1 and 2 of Big Creek, Units 1 and 2 of Sweathouse Creek and Units 1 and 2 of Bass Creek, but were not documented using tracking stations in either Unit 1 or 2 of Bear Creek (Figure 18). Latency to detection for fisher at closed tracking stations was 8 days and 2 days for Bear Creek Units 1 and 2, respectively, and 6 days for Unit 2 in Big Creek. Mean latency to detection for fishers using closed tracking stations was $\bar{x}$ = 5.3 days (given the 2-day interval for checking stations) (Table 4). Continuous heavy rains during the Bear Creek/Big Creek survey precluded obtaining usable data on fisher from open stations in these drainages and no fisher were recorded in

Sweathouse Creek or Bass Creek where open stations were successfully employed. Mean latency to detection for marten was $\bar{x}$ = 3.3 days for closed stations and $\bar{x}$ = 2.3 days for open stations (Table 4).

Table 4. Latency to detection for marten (*Martes americana*) and fisher (*Martes pennanti*) using open and closed tracking stations to survey 8 1-mile^2 units in 4 drainages on the Bitterroot National Forest. A dash indicates a unit where no detections occurred for the given species.

		Species and tracking station type			
		Martes americana		*Martes pennanti*	
Location	Unit	closed	open	closed	open
Bear Creek	1	-	-	8	*
	2	-	-	2	*
Big Creek	1	4	2	-	-
	2	2	2	6	-
Sweathouse Creek	1	4	4	-	-
	2	2	2	-	-
Bass Creek	1	4	2	-	-
	2	4	2	-	-
$\bar{x}$ ± se		3.3 ± 0.4	2.3 ± 0.3	5.3 ± 1.8	

* Fisher were recorded at open tracking stations 3 and 10 in Units 1 and 2, respectively, by print stains left on rain-washed plates. Open stations were not checked during heavy rains, so it is not known when these plates were visited.

In Bear Creek, fishers made 3 visits to 2 tracking stations in Unit 1 and 18 visits to 4 stations in Unit 2 (Table 5). Most observations were from closed sets (2 in Unit 1 and 17 in Unit 2) because consistent heavy rain rendered open stations ineffective. Only 2 observations came from open tracking stations. Both were the result of print stains left on the open plates after carbon had been washed away. It is not known when the 2 stations were

Table 5. Bear Creek tracking plate survey results. Common names are given where target species were detected. The dotted line divides Unit 1 (stations 1-6) from Unit 2 (7-12). "c" or "o" indicates whether the station used a closed or an open tracking plate. All odd numbered stations were on the south side of the creek while all even numbered stations were on the north side of the creek.

Tracking station	Days since tracking stations were set out						
	2	4	6	8	10	12	14
1 c	-	-	-	-	-	-	-
2 o	Rain	Rain	Rain	Rain	Rain	Rain	Rain
3 o	Rain	Rain	Rain	Rain	Rain	Rain	Fisher♀ [2]
4 c	-	-	-	-	-	-	-
5 c	-	-	-	Fisher♂	Fisher♂	-	-
6 o	Rain	Rain	Rain	Rain	Rain	Rain	Rain
7 o	Rain	Rain	Rain	Rain	Rain	Rain	Rain
8 c	Fisher♀	Fisher♀	Fisher♂	Fisher♂	Fisher♂	-	-
9 c	-	Fisher [1]	-	Fisher♀	Fisher2	-	-
10 o	Rain	Rain	Rain	Rain	Rain	Rain	Fisher♂ [2]
11 o	Rain	Rain	Rain	Rain	Rain	Rain	Rain
12 c	Fisher♀	Fisher♂	Fisher2	Fisher2	Fisher2	-	-

1 - The bait was removed from the back of this set and no prints were left on the contact paper or the aluminum plate. Since no marten were recorded at any sets in this unit and since fisher visited this set as well as those around it, we believe this visit was by a fisher.

2 - When tracking stations were pulled, print stains were found on plates at open stations 3 and 10. Since open stations were not checked after the initial days of the survey due to continuous heavy rains, it is not known when these 2 stations were visited.

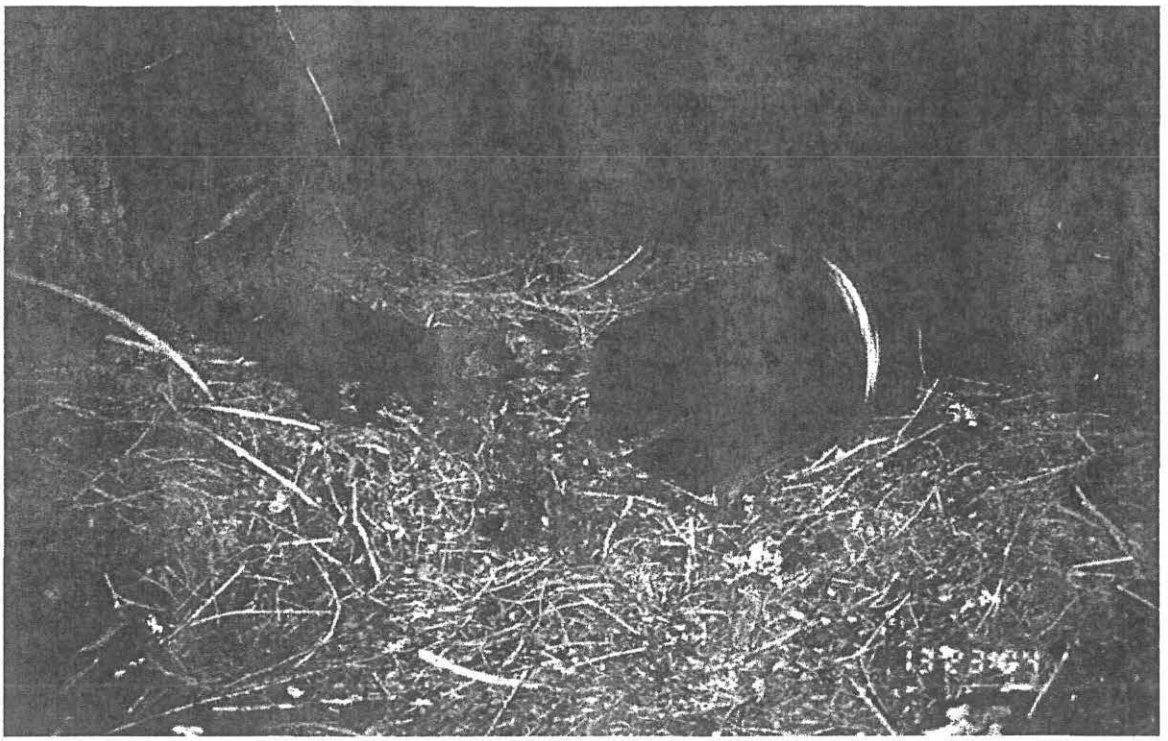


Figure 17. A fisher approaching a closed tracking plate.

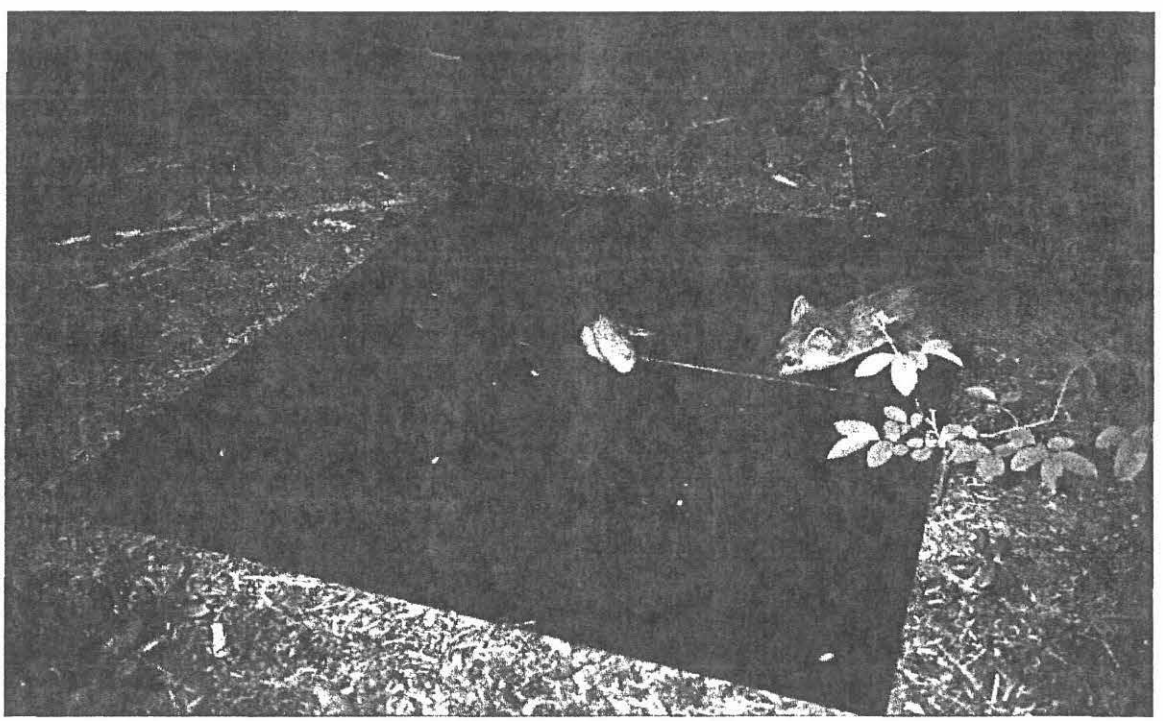


Figure 18. A marten stepping on to an open tracking plate.

visited, because open stations were not checked, due to rain, until they were collected at the end of the survey.

At least 2 fishers visited tracking stations in Bear Creek Units 1 and 2 (Table 5). One fisher, identified by a distinctive cut on the second digit of the left front foot and a similarly unique mark (a crease) on the 3rd interdigital pad of the same foot, was clearly a large mature male as indicated by its high discriminant scores (Appendix 6). Other fisher prints were likely from a single female given the relative size and the spatial and temporal overlap of occurrence with the male. These 2 individuals entered the same sets over the same 2-day interval on 4 occasions.

The larger fisher was recorded twice at closed station 5 in Unit 1 and 9 times at 4 stations in Unit 2. The smaller fisher visited 3 stations 8 times in Unit 2 and was believed to have visited 1 open station in Unit 1 where it left a print stain. Crude measurements were taken of this print to the nearest 1.0 mm using a hand ruler in the field. The measurements (WI3 = 11, LI3 = 9, LI4 = 7) closely matched those for the smaller fisher taken from closed stations in Unit 2 (see Appendix 6).

Bait was stolen from the back of station 9 in Unit 2 by what was believed to be 1 of these fishers, since both fishers were recorded later at this plate and others nearby and no marten were recorded in the area. Bait was also stolen from the back of station 12, but a print on the front edge of the aluminum plate identified the perpetrator as the smaller fisher. Pine marten were not detected in either unit of Bear Creek using tracking plates although they were detected in both Units 1 and 2 of this drainage during remote-sensing camera surveys that ran from 11/30/94 - 01/25/95 (see Section 1: Remote-Sensing Camera Survey).

Seventeen sets of prints were left on contact paper by the Bear Creek fishers. Of these, 15 provided sufficient detail for the measurements necessary to apply the classification algorithm of Zielinski and Truex (1995)(Figure 19). Measurements were made

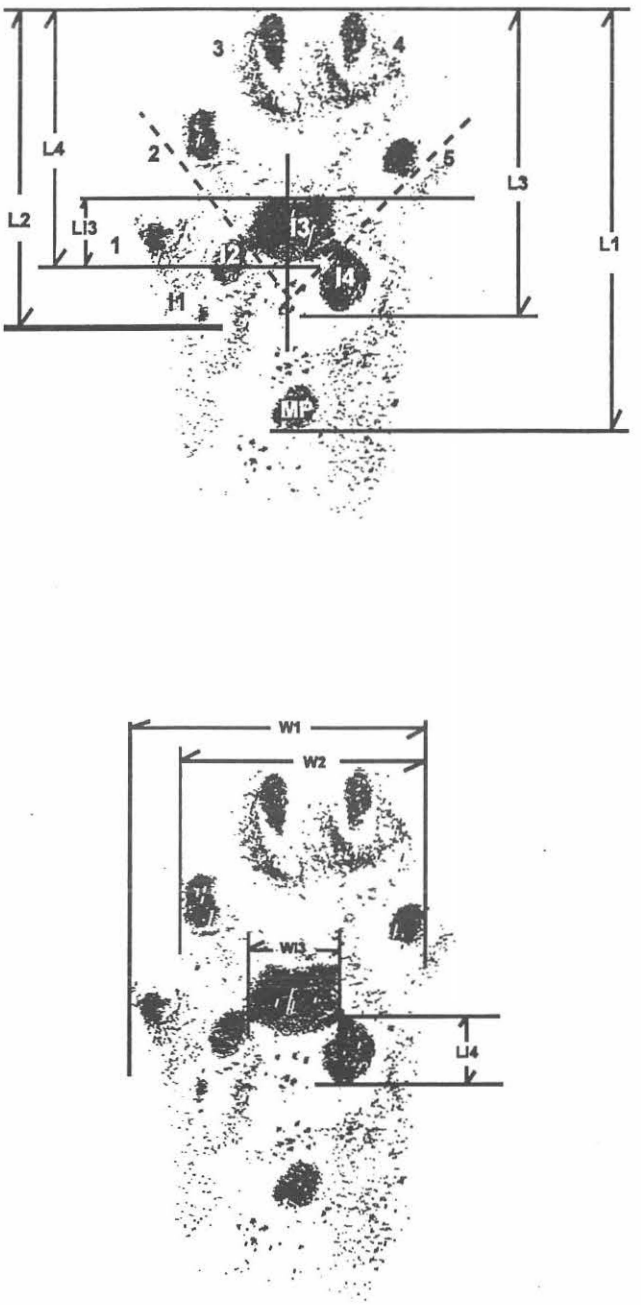


Figure 19. Right forefoot impression of representative fisher illustrating common length and width measurements to which the classification algorithm of Zielinski and Truex (1995) was applied. Digits numbered 1 to 5; interdigital pads I1 to I4; metacarpal pad, MP. For a description of the measurements refer to text, pages 36-37.

of right and left forefeet. Means and standard deviations of discriminant function scores for the larger fisher were $\bar{x}$ = 58.1 ± 4.7 and $\bar{x}$ = 44.5 ± 8.0 for right and left feet respectively and $\bar{x}$ = 14.8 ± 7.2 and $\bar{x}$ = 15.8 ± 9.3 for the smaller fisher (Table 6). Individual measurements and discriminant scores are given in Appendix 6.

Table 6. Summary statistics of fisher discriminant function scores obtained by applying the discriminant function algorithm of Zielinski and Truex (1995) to fisher tracks on contact paper collected from closed tracking stations in Big Creek and Bear Creek. The standard deviation (SD) of 0.0 indicates a SD < 0.05. The assumption was made that 3 individuals made the tracks; the tracks are summarized by these 3 individuals.

Fisher	Location	Foot	$\bar{x}$	SD	n
1	Bear Creek	L	44.5	8.0	6
1	Bear Creek	R	58.1	4.7	4
2	Bear Creek	L	15.8	9.3	6
2	Bear Creek	R	14.8	7.2	6
3	Big Creek	L	10.9	0.0	2
3	Big Creek	R	7.1	8.4	2

In Big Creek, 1 fisher was recorded once at closed tracking station 11 at the upper boundary of Unit 2. Four prints were measured from this set of tracks: 2 right and 2 left. Means and standard deviations of discriminant scores for this fisher were $\bar{x}$ = 7.1 ± 8.4 and $\bar{x}$ = 10.9 ± 0.0 for right and left feet respectively (Table 6). Individual measurements and scores are given in Appendix 6. Marten entered 1 closed tracking station once in Unit 1, and 2 closed tracking stations 7 times in Unit 2 during the 12-day survey of Big Creek (Table 7). Closed stations 3 and 6 in Unit 1 were visited by marten on the 14th day, 2 days after the official survey had ended. The visit to station 6 was the first record of marten at this station. Weasels (*Mustela sp.*

Table 7. Big Creek tracking plate survey results. Common names are given where target species were detected. The dotted line divides Unit 1 (stations 1-6) from Unit 2 (7-12). "c" or "o" indicates whether the station used a closed or an open tracking plate. All odd numbered stations were on the south side of the creek while all even numbered stations were on the north side of the creek.

Tracking station	Days since tracking stations were set out						
	2	4	6	8	10	12	14
1 o	Rain	Rain	Rain	Rain	Rain	Rain	Rain
2 c	-	-	-	-	-	-	-
3 c	-	Marten	-	-	-	-	Marten
4 o	Marten [1]	Rain	Rain	Rain	Rain	Rain	Rain
5 o	Rain	Rain	Rain	Rain	Rain	Rain	Rain
6 c	-	-	-	-	-	-	Marten
7 c	-	-	Marten	-	-	-	
8 o	Rain	Rain	Rain	Rain	Rain	Rain	
9 o	Rain	Rain	Rain	Rain	Rain	Rain	
10 c	Marten	Marten	Marten	Marten	Marten	Marten	
11 c	-	-	Fisher	-	-	-	
12 o	Marten [2]	Rain	Marten [3]	-	-	-	

1 - Plates had been washed clean of carbon, but prints had stained the plates.
2 - Plates had been washed clean of carbon, but marten tracks were identified at the plates in fresh snow and the bait had been taken.
3 - Plates had been washed clean of carbon, but marten scat was present on the plates.

[probably *M. erminea*]) were recorded 4 times at closed stations 3, 6 and 7. On 2 occasions weasels overlapped with marten at station 7. Eight sets of tracks were collected on contact paper for target species (7 marten and 1 fisher) and 4 sets were collected for weasels. Ten prints were measured to obtain discriminant function scores (Appendices 6 and 7 for fisher and marten respectively), including 4 prints taken from the single set of fisher tracks.

Pine marten were recorded at 2 open tracking stations, station 4 in Unit 1 and station 12 in Unit 2, but consistent rain over the period of the survey precluded obtaining further information from open tracking stations in Big Creek. Marten tracks observed in fresh snow next to open station 12 in conjunction with the absence of the bait, indicated this station had been visited by marten on the 2nd day of the survey. This station was visited again on the 6th day of the survey as evidenced by the presence of marten scat on the plate. At station 4, print stains were left on rain-washed plates on day 2. Prints were only recorded on rain-washed plates 3 times during the entire survey. Prints were usually washed off plates along with the carbon.

Marten were recorded in Sweathouse Creek at every station except open tracking station 4 (Table 8). Two closed stations, 2 and 3, did not produce marten until the final day of the survey. Nine sets of tracks were collected on contact paper from closed stations. Of these, 7 prints were of sufficient quality for determining discriminant function scores (Appendix 7). An additional print was collected from station 7 using the tape method described above for open stations. This animal did not completely enter the station and field identification of the print was uncertain. The print was later identified as belonging to a marten (score = -10.05). Marten visiting open plates in Sweathouse Creek marred tracks through multiple visits or extended visits to the stations. No prints were collected from open tracking stations in this drainage, however, all prints were

Table 8. Sweathouse Creek tracking plate survey results. Common names are given where target species were detected. The dotted line divides Unit 1 (stations 1-6) from Unit 2 (7-12). "c" or "o" indicates whether the station used a closed or an open tracking plate. All odd numbered stations were on the south side of the creek while all even numbered stations were on the north side of the creek.

Tracking station	Days since tracking stations were set out					
	2	4	6	8	10	12
1 o	Rain	Marten [1]	-	Marten	Rain	Rain
2 c	-	-	-	-	-	Marten
3 c	-	-	-	-	-	Marten
4 o	Rain	Rain	-	-	Rain	Rain
5 o	Rain	Marten [1]	Marten	Marten	Rain	Rain
6 c	-	Marten	-	-	Marten	Marten
7 c	Marten	-	-	Marten	-	Marten
8 o	-	Rain	Rain	-	Marten	Rain
9 o	-	Rain	Rain	Marten	Marten	Rain
10 c	-	-	-	-	Marten	Marten
11 c	-	-	-	-	Marten	-
12 o	Marten	Rain	Rain	-	-	Rain

1 - Plates had been washed clean of carbon, but marten scat were on plates.

small and none were believed to be fishers.

Bass Creek produced marten at all open tracking stations and at 50% of the closed stations (Table 9). No target species were recorded at closed stations 6, 10 and 11 during the 12-day survey. Six sets of prints were collected from closed stations 2 and 7 in Bass Creek. Discriminant scores were calculated for all 6 (Appendix 7). Four sets of tracks were collected from open tracking stations 1, 5, 9 and 12. Discriminant scores were also calculated for 2 of these (Appendix 7).

Open and closed tracking plates successfully recorded marten and fisher in all drainages where remote camera surveys and snow tracking indicated these species were present. Neither wolverine nor lynx visited tracking stations. Although the camera survey indicated a wolverine was present in upper Sweathouse Creek, the extensive movements notable for this species (Hornocker and Hash, 1981; see Butts, 1992 for review) could explain its absence from the tracking plate survey. Increased availability of food such as ground squirrels (*Spermophilus* spp.) (due to emergence) and carrion (due to thaw) in spring may decrease the allure of baits for this species and thus account for its absence from the tracking plate survey. Both explanations suggest potential weaknesses of the tracking plate survey protocol/methodology for wolverine: 1) the shorter duration (14 days) may afford an inadequate window for a wolverine to "make its rounds" through its home range; 2) susceptibility of wolverine to baits may decline in spring as natural foods become more available. However, the low wolverine activity we observed renders such speculation inconclusive and conducting another survey in the fall as per the protocol of Zielinski (1995) would increase the probability of detecting this species. Since lynx were not observed with any method, we assume they were absent from the survey area.

Comparison of open and closed tracking stations:

Due to excessive rain during the Bear Creek/Big Creek survey

Table 9. Bass Creek tracking plate survey results. Common names are given where target species were detected. The dotted line divides Unit 1 (stations 1-6) from Unit 2 (7-12). "c" or "o" indicates whether the station used a closed or an open tracking plate. All odd numbered stations were on the south side of the creek while all even numbered stations were on the north side of the creek. An "X" indicates the bait was removed, but tracks could not be identified.

Tracking station	Days since tracking stations were set out					
	2	4	6	8	10	12
1 o	Marten	Marten	Rain X	Not set X	Marten	Marten
2 c	-	-	-	Marten	-	-
3 c	-	Marten	-	-	-	-
4 o	Marten	-	Rain X	-	-	Marten
5 o	Marten	-	Rain X	Marten	Marten	Marten
6 c	-	-	-	-	-	-
7 c	-	Marten	Marten	Marten	Marten	Marten
8 o	Marten	Rain	Marten	Marten	-	Rain
9 o	Marten	Marten [1]	Marten	Marten	Marten	Rain
10 c	-	-	-	-	-	-
11 c	-	-	-	-	-	-
12 o	Marten	Marten [1]	-	Marten	-	Rain

1 - Plates had been washed clean of carbon, but marten scat was present on the plates.

open and closed tracking stations could only be compared using data from Sweathouse Creek and Bass Creek. Since only marten were observed in these drainages, comparisons were made only for this species. Over the first 2-day period there was no rain in Bass Creek Units 1 and 2 or in Sweathouse Creek Unit 2. During this interval, 67% (6 of 9) of the open tracking plates were visited by pine marten, whereas marten visited only 11% (1 of 9) of the closed tracking plates (Figure 20). The only closed tracking plate visited was not entered completely and the bait was not taken. This animal left a print only on the carboned plate. Most open plates were quickly visited by marten and new stations continued to be visited until marten had been recorded at 92% of the open tracking stations by the end of the 12-day survey. Initially, few closed tracking plates showed evidence of marten presence. By the half-way point of the survey, 33% of the closed stations had been visited by marten compared with 75% for open stations. Visitation of previously unused plates by marten increased over the last half of the survey for closed stations until 75% of the stations were visited by the end of the survey compared with 92% for open tracking stations (Figure 20).

First recorded visits by marten to closed tracking stations resulted in animals stepping only on the carboned tracking plate (no prints left on contact paper) 36% of the time. The first 2 days of the Sweathouse Creek/Bass Creek tracking plate survey produced visits at 11% of closed stations compared with 67% of open stations. Given the checkerboard arrangement of open and closed plates within a unit, the rapidity with which marten responded to open plates, and the high percentage of marten which only partially entered closed sets on the first recorded visit, the difference between visitations to open and closed tracking stations suggests marten demonstrate a bias against the latter. Fishers may also exhibit this bias as 1 of 3 fishers (33%) only partially entered sets on their first recorded visits. We believe this bias results from an initial reluctance exhibited by marten and possibly fisher toward entering closed tracking

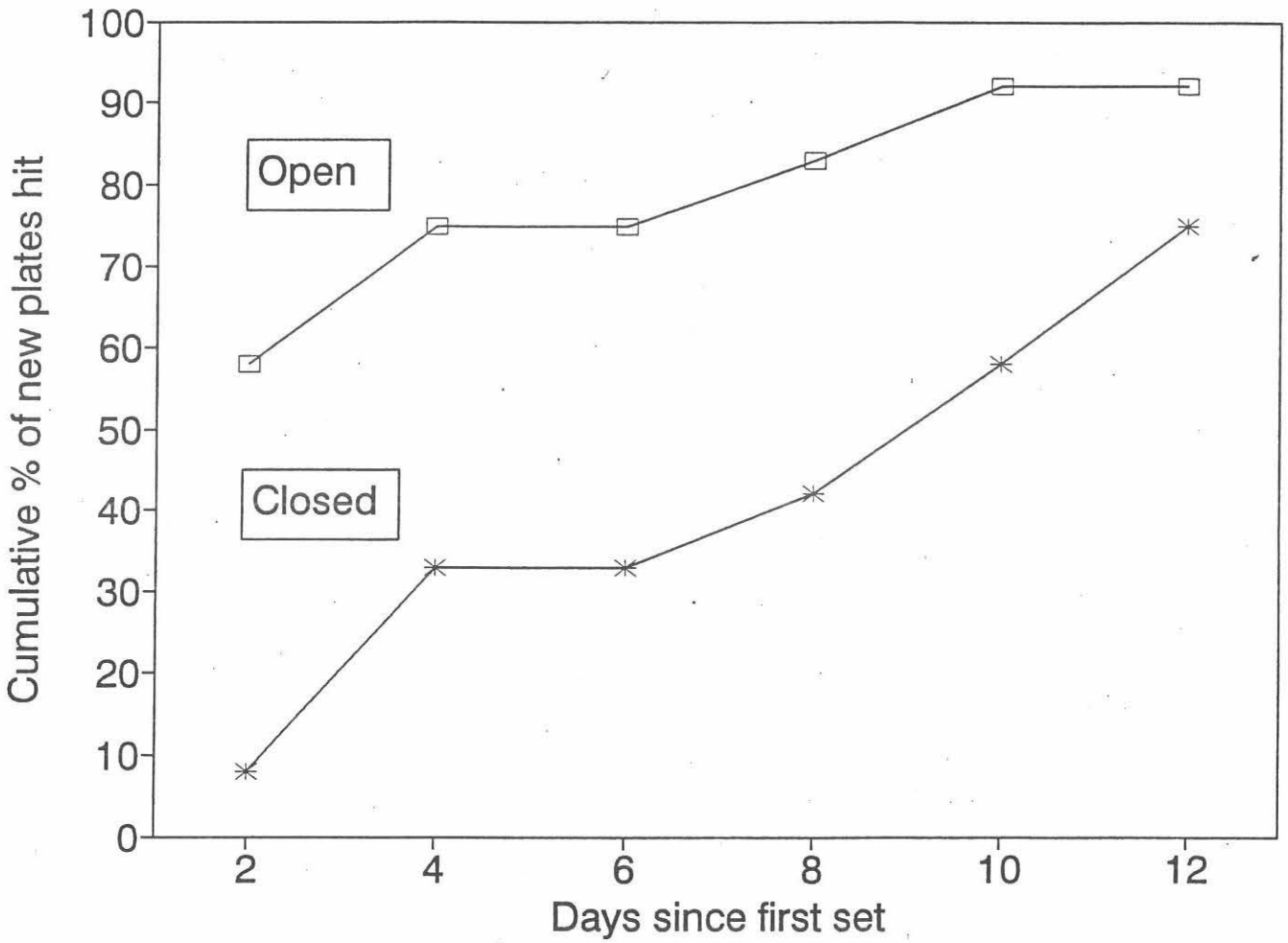


Figure 20. Comparison of the cumulative number of open and closed tracking plates visited by marten in Sweathouse Creek and Bass Creek drainage.

stations. Animals may visit closed stations several times before entering to retrieve the bait thereby incurring a detection. Depending on the timing of the initial visit relative to the survey period, this bias could conceivably result in missing observations and wrongly concluding that the target species are absent from a survey site.

In addition to the bias against initially entering closed tracking plates, an interspecific bias may also affect tracking plate surveys. We observed no marten at tracking stations where fisher occurred (n = 5, excluding open stations). Conversely, no fisher occurred at stations visited by marten (n = 4, excluding open stations). Marten were not recorded in Bear Creek during the spring when tracking plates indicated fisher activity was high, even though camera surveys demonstrated marten were quite active in winter, and late spring camera testing indicated that marten were still present after the tracking plate surveys ended.

Because fisher only occurred in drainages where rain nullified the effects of open tracking plates, we are uncertain whether this apparent interspecific bias also occurs at open stations. However, all cameras which recorded fisher also recorded marten (n = 3) and it seems unlikely that open tracking stations affect these species any more than camera stations. Given the apparent apprehension with which marten enter closed tracking stations, the presence of fisher scent at a closed station may exacerbate avoidance behavior.

Interspecific bias toward tracking plates may result from domination of marten by fisher due to interference competition or predation exerted by the larger fisher on the marten. Fisher occasionally kill marten (de Vos, 1952; Raine, 1981) and would clearly dominate in competitive interactions. Therefore, if an interference bias exists it probably results in a bias against marten, i.e., visitation of closed stations by fishers may preclude marten observations at those sites. Since fisher are generally rarer than marten and thus a greater management priority, they will likely be a higher priority target species of

surveys especially if evidence already exists for the presence of marten. In such cases this bias may be unimportant. However, if managers implement tracking plate surveys to target marten where fisher occur, they should seriously consider this potential bias.

Biases against closed plates exhibited by marten and possibly fisher suggest open plates may serve as a more effective survey method if precipitation can be predicted reasonably well based on local weather patterns and season. Even with occasional heavy rains during a survey, as was the case during the Sweathouse Creek/Bass Creek survey, open tracking plates outperformed closed plates for pine marten detections. However, continuous rain renders open plates virtually useless. Nonetheless, even in heavy rains open plates may produce some evidence of visitation. On 3 occasions marten and fisher left print stains on open plates during periods of heavy rain and marten left scats on or next to plates numerous times when plates had been washed clean of tracks. Therefore, a combination of open and closed tracking plates may prove most fruitful.

Open plates offer the added potential for detecting wolverine and possibly lynx. These species seem to be excluded by the small openings of closed plates as evidenced by their absence from closed tracking plate surveys (Zielinski, 1995). Open plates with high covers might offer a solution to the problem of precipitation, but covers of any sort could result in avoidance behavior by target species. Such a design should be tested.

Greater latency to detection times resulting from bias against closed plates by marten and possibly fisher suggests that longer survey times may be necessary when using closed tracking plates. In this manner a level of certainty, with an equal probability to that of open plates, that target species are not present may be achieved. In Unit 1 of Big Creek a marten was identified by a print stain on day 2 at open station 4 which was located adjacent to 2 closed stations that did not detect marten until after the 12-day survey had ended. We recommend running

marten and fisher tracks resulting from these factors. Biologists should be aware that some unknown degree of error will occur. Assignment of species to tracks collected in the field may be considerably less than 100%.

CONCLUSIONS AND RECOMMENDATIONS

Given the biases identified for both open and closed tracking plates we recommend that both methods be employed to enhance chances of species detection. It may be necessary to lengthen survey times beyond 12 days particularly where closed plates are being used.

We recommend making measurements from original tracks rather than photocopies, as suggested by Zielinski and Truex (1995), as they retain fine details that are important for accuracy.

Where fisher and marten are found in sympatry caution must be taken when applying the classification algorithm of Zielinski and Truex (1995). Under field conditions a significant percentage of tracks may not be clean enough to make meaningful identifications.

We recommend scheduling track plate surveys as late as possible in the fall or winter to increase the size differences between subadult male martens and female fishers.

Closed tracking stations should be set flush against a tree, log or rock. Logs work best although gaps occur at the top and bottom of the back due to the curve of the log. These gaps are easily filled with sticks and branches. Marten and fisher will remove baits without entering stations where gaps are present.

For remote surveys, we found the portable acetylene torch very effective. The torch and other equipment required for checking stations results in a comfortable pack weight of about 45 lbs, and frees field personnel from the difficult task of transporting plates into the field without disturbing the carbon coating. The torch, especially the neck, should be well protected from damage due to a fall. We tied a foam sleeping pad tightly around ours. This protected the torch while providing

easy access to attach and remove the gauges. We advise extreme caution when using a torch in the field especially in the fall if conditions are dry.

SECTION 3: SNOW TRACKING SURVEY

METHODS

We conducted snow tracking surveys from 01/09/95 to 03/08/95. We conducted surveys on foot or by snowshoe along United States Forest Service trails which bisected each survey unit. Each 1-mi. section of trail (within the sample unit) was divided into 4, 1/4-mi. segments by pacing the distance and flagging the segment boundaries. For each segment we counted the number of tracks that crossed the trail for the following species: weasels (*Mustela* spp.), marten (*Martes americana*), fisher (*Martes pennanti*), lynx (*Lynx lynx*), wolverine (*Gulo gulo*), coyote (*Canis latrans*), and mountain lion (*Felis concolor*). We assigned red squirrel (*Tamiasciurus hudsonicus*) and snowshoe hare (*Lepus americanus*) tracks to an abundance category accordingly: absent = 0, T (trace) < 5, P (present) = 5 to 9, 1 = 10 to 19, 2 = 20 to 29, 3 = 30 to 39, 4 = 40 to 49, 5 = 50 to 59, 6 = 60 to 69, 7 = 70 to 79, 8 = 80 to 89, 9 = 90 to 99, 10 = 100 to 109, 11 = 110 to 119, 12 = 120 to 129, 13 = 130 to 139, 14 = 140 to 149, 15 = 150 to 159. Abundance was estimated for these species by using the median from each category (eg. category 1 = 15, P = 7.5).

We surveyed for tracks approximately 2 days after new snow. For logistical reasons this varied between 1 and 3 days. At least 2 mm of new snow were generally necessary to distinguish new prints from old ones.

We measured length and width of prints, and measured stride, group, and straddle along trails using the minimum outline method described by Halfpenny et al. (1994) except that we tried to collect 5 rather than 3 measurements for each track or gait

dimension. Halfpenny et al. (1994) and Halfpenny and Biesiot (1986) served as references for track identification. We collected print and gait measurements whenever possible during field work, but official snow tracking surveys were restricted to canyons without baited camera stations to avoid the bias of baiting. We attempted to measure tracks from the first representative of each species encountered within a unit for verification purposes.

We photographed tracks and created plaster casts for permanent records. We constructed casts by carefully spraying a layer of Snow Print Wax (Kinderprint Co. Inc., P.O. Box 16, Martinez, CA 94553, 800-227-6020) over a well-defined track. We then mixed and poured plaster of Paris into the track, covered it with newspaper and snow for insulation and protection, and removed the plaster cast after approximately 45 min. (see Halfpenny et al., 1994). Plaster casts were wrapped in newspaper and placed in a plastic container for transport.

We analyzed the relationship between predators (weasels and marten) and prey (squirrels and snowshoe hare) using simple linear regression based on the assumption of dependence of predators on prey. The relationship between the 2 prey species (squirrels and snowshoe hares) and the 2 predators (weasels and marten) was analyzed using the Pearson product-moment correlation coefficient instead of regression due to the lack of biological justification for dependence within variable sets. Data Desk (Velleman, 1988) was used for statistical analyses.

RESULTS

We successfully conducted 9 surveys in the 4 drainages: 3 in Bear Creek; 3 in Sweathouse Creek; 1 in Bass Creek; 2 in Big Creek. Numerous other attempted surveys failed and were canceled due to poor tracking conditions. Windows of time when good conditions for snow tracking occurred were often too brief (≤1 day) to include multiple surveys.

Prints:

Print measurements were not collected from marten tracks because extremely few marten prints provided sufficient detail for these measurements. One fisher left a distinct set of prints in 1 cm of fresh snow on a layer of smooth ice. Mean length and width of 5 left hind prints were 61.2 mm (SD = 1.72) and 59.4 mm (SD = 4.32). Halfpenny et al., (1994) gives a minimum outline length of 55 mm and width of 61 mm from a single fisher foreprint and a variable outline length of 62 mm (SD 2.6) and width of 56 mm (SD = 2.4) for hindprint measurements from 3 fishers. They do not give minimum outline measurements for a fisher hindprint. Length was measured from the anterior-most point of the toe pads to the posterior-most point of the first metatarsal pad. These tracks were confirmed as belonging to a fisher by backtracking the trail to a camera station where the animal had been photographed. Based on numerous photographs of this individual obtained from a remote sensing camera, we conclude from its large size that it was an adult male. These measurements likely represent the upper size range for fisher in the northern Rocky Mountains. Photographs were taken of the fisher trail and prints, and of several marten trails.

Trails:

Gaits provided the most consistent means for identification of fisher and marten tracks and, of these, the group measurement was the most consistently obtained. The group measurement was made for all 7 marten and 1 of 2 fisher (Tables 10 and 11). Stride and straddle measurements were obtained for 6 of the 7 marten (Table 10). Stride was measured for 1 fisher track and straddle was measured for both (Table 11). Variability was lower for group and straddle measurements relative to stride as indicated by the lower standard deviations. Animals were verified visually or by photographs when tracks were followed to or measured at camera stations.

Table 10. Individual and population summary statistics for group, stride, and straddle measurements made on 7 martens. Measurements are in centimeters.

Animal	Species confirmed	Group			Stride			Straddle		
		$\bar{x}$	SD	n	$\bar{x}$	SD	n	$\bar{x}$	SD	n
1	Yes	21.5	3.0	5	64.7	14.6	5	8.3	1.0	5
2	No	12.7	1.1	5			0			0
3	Yes	18.4	2.1	5	63.8	7.7	5	6.9	1.2	5
4	No	8.8	1.2	5	53.5	10.0	5	8.2	0.6	5
5	No	13.0	2.6	5	56.5	4.1	5	6.3	0.4	5
6	No	10.3	1.0	3	91.0	52.3	2	9.6	2.4	3
7	No	16.2	1.5	5	54.2	2.0	4	7.1	0.8	5
Pop. $\bar{x}$ and SD		14.4	4.5	7	64.0	14.1	6	7.7	1.2	6

Table 11. Individual and population summary statistics for group, stride, and straddle measurements made on 2 fishers. Measurements are in centimeters.

Animal	Species confirmed	Group			Stride			Straddle		
		$\bar{x}$	SD	n	$\bar{x}$	SD	n	$\bar{x}$	SD	n
1	Yes	54.1	1.3	5	71.6	5.1	5	11.9	1.5	5
2	Yes							15.8	2.5	5
Pop. $\bar{x}$ and SD		54.1		1	71.6		1	13.9	2.8	2

Survey Results:

Weasels were observed in all units except Bass Creek unit 2 (Table 12). Marten were not detected in Unit 2 of Bear Creek or Unit 2 of Bass Creek. Fisher went undetected in all survey units, but a possible fisher was identified between units 1 and 2 in Sweathouse Creek. This individual was tracked for about 1 km and used a predominantly 3x gait. The 2 other confirmed fishers in the study area also favored a 3x gait whereas marten tended to use a 2x gait most of the time. However, print measurements from this individual were not definitive (left hind foot measurements

for 4 prints were length = 42 mm [SD = 2.0], width = 43 mm [SD = 4.0]; 1 right front print measured 39 mm [length] and 36 mm [width]) being small for a fisher. This individual was excluded from Tables 2 and 3 because of the uncertainty of its identification.

Although coyotes were present in all survey units, they were only detected in units 1 and 2 of Bear Creek, Unit 1 of Sweathouse Creek, and units 1 and 2 of Bass Creek during the snow tracking survey. We identified mountain lion tracks in the lower units of Sweathouse Creek and Bass Creek, but knew lions to be present in units 1 and 2 in Bear Creek and Big Creek, and tracks were found very close to Unit 2 in Sweathouse Creek. Snowshoe hares and red squirrels were identified in all survey units though abundance of tracks varied greatly among units and among surveys within units (Table 12). Neither wolverine nor lynx were detected during snow tracking surveys, though a wolverine was present in upper Sweathouse Creek as documented in the camera survey results (Chapter 1).

Snow tracking failed to detect marten in 2 of 7 units, fisher in 4 of 4 units, and wolverine in 1 of 1 units where these species were known to occur. Snow tracking similarly failed to detect nontarget species including mountain lions in 4 units and coyotes in 3 units where they had otherwise been detected.

Simple linear regression of predators on prey showed no significant relationship between abundance of marten or weasels with snowshoe hare or red squirrels (Table 13). Pearson product-moment correlations indicated a similar lack of correlation between prey species ($r^2 = 0.073$). However, the 2 predators showed a very strong positive linear relationship ($r^2 = 0.947$). These results suggest that a common habitat or more likely a common prey source, not analyzed here, is similarly affecting the activity or abundance of these 2 species as indicated by track counts. Both species are probably keying in on concentrations of microtine rodents, since this is a common and integral dietary component for both marten and long-tailed weasels.

Table 12. Summary statistics (means and standard deviations [in parentheses]) for track abundance from snow tracking surveys conducted in 4 drainages on Bitterroot National Forest.

Creek	Unit	*Muserm*	*Marame*	*Canlat*	*Felcon*	*Tamhud*	*Lepame*
Bear	1	1.1 (1.0)	0.3 (0.3)	1.0 (1.7)	0	22.8 (26.0)	14.4 (10.3)
	2	1.6 (1.7)	0	1.7 (1.7)	0	11.0 (12.2)	11.9 (11.7)
Sweathouse	1	0.4 (0.2)	0.6 (0.8)	1.2 (0.3)	0.1 (0.1)	34.6 (28.9)	6.8 (6.1)
	2	6.9 (8.3)	6.8 (0.0)	0	0	9.4 (9.7)	22.5 (21.2)
Big	1	0.6 (0.9)	1.3 (1.8)	0	0	2.5 (0.0)	13.8 (2.7)
	2	0.9 (0.2)	0.3 (0.4)	0	0	4.1 (2.2)	3.1 (0.9)
Bass	1	2.8 (2.5)	1.8 (1.1)	0.8 (1.1)	0.1 (0.2)	16.6 (4.9)	80.3 (59.7)
	2	0	0	1.0 (0.0)	0	9.4 (0.0)	9.4 (0.0)

Muserm = Short-tailed weasel
Marame = Marten
Canlat = Coyote
Felcon = Mountain lion
Tamhud = Pine squirrel
Lepame = Snowshoe hare

Table 13. Results of simple linear regression analyzing interactions between predators and prey based on track abundance estimates.

	Statistic			
Species interaction analyzed	r^2	df	t	P
Tamhud vs *Muserm*	0.02	6	0.362	0.730
Tamhud vs *Marame*	0.03	6	0.400	0.702
Lepame vs *Muserm*	0.13	6	0.933	0.387
Lepame vs *Marame*	0.06	6	0.635	0.549

Tamhud = Red squirrel
Musame = Marten
Muserm = Short-tailed weasel
Lepame = Snowshoe hare

Wolverine tracks:

We measured wolverine prints at camera stations and along a wolverine's trail on 02/14/95. Although we followed the individual for approximately 1.5 km, the trail, made during a blizzard, offered few clear prints. The combination of snow blowing into tracks and backtracking by the animal distorted the trail and precluded measurements of gait. Measurements compare to Halfpenny et al. (1994)

Wolf tracks:

We identified wolf (*Canis lupus*) tracks in Unit 1 of Big Creek on 02/16/95 starting about 400 m from the trailhead. This location was ≥13 km from the nearest residence and tracks indicated neither vehicles nor people had visited the trailhead for 3 days. The animal moved along a straight stretch of trail at a steady walking pace with the hind feet registering directly in the front tracks for about 50 m. Tracks were fresh (approximately 2 - 3 hrs old) and left clearly defined prints in the wet snow. The extremely low variability of measurements attests to the quality of tracks and conditions of this observation.

Length and width of right hindprints averaged 9.3 cm (SD =

0.4) and 8.3 cm (SD = 0.6) respectively for 5 tracks measured. Gait measurements averaged 128.9 cm (SD = 0.3) for stride and 76.5 cm (SD = 0.8) for group. Straddle was not measured. Halfpenny and Biesiot's (1986) measurements for the larger front foot of wolves are: length 12.1 cm; width 10.2 cm. They provide a measurement for stride of 102 cm.

This animal followed the trail for about 0.5 km before veering north to the edge of Big Creek. It followed the creek for 150 to 200 m attempting unsuccessfully to cross twice before eventually negotiating a precarious ice jam. In skirting the creek, the animal traveled along several narrow, snow-covered logs; this is unlikely behavior for a domestic dog (*Canis familiaris*) of this size. A recent lion kill (a mule deer [*Odocoileus hemionus*] doe), about 1 - 3 hrs old at the time of the crossing, was found on the other side of the creek within 0.5 km the crossing site. We believe the wolf was approaching the kill site, but its tracks were lost in the confusion of lion tracks (3 lions made the kill) at the kill site.

DISCUSSION

Variability and its affect on interpretation of data:

Variability in estimates of track abundance was high due to variation in the track-deposition interval (interval between snowfall and snow tracking) and variation in animal activity after snows. Animal activity varied greatly after snow events probably due to storm intensity, duration, and post-storm conditions. Because only a single drainage could be tracked on any given day to take advantage of the limited snows that resulted in good tracking conditions, the alternate drainage was tracked 1 day before or after the second day following a snow. These factors are best addressed through careful interpretation of the data. Comparisons made among species by unit are justified because track-deposition interval and weather conditions affecting activity are controlled among species (given a minimum

24 hr deposition interval so that all species [nocturnal and diurnal] have a comparable period of time to move about). However, comparisons among drainages and even between units within a drainage require caution owing to variability in track-deposition intervals (among drainages) and the quality of tracking conditions at different elevations and at different times of the day (between units within drainages). These considerations apply broadly to any inferences based upon snow tracking data.

Additional sources of variability are listed in Table 14. Variation in snow conditions was controlled for in this study by canceling snow tracking surveys when conditions were poor to bad. However, this is not always an option, and poor snow conditions can contribute to variation in the ability to distinguish between species, result in an inability to identify a species with confidence, and reduce the ability to discern tracks when the crust is hard or transects pass through patchy snow beneath a heavy forest canopy. Snow tracking requires training and experience for trackers to be effective and consistent. Inexperienced observers and inconsistency within and between observers introduces not only variability, but also error to tracking results. Distinguishing between marten and fisher and between lynx and mountain lions can be difficult especially in poor snow conditions. Even under the controlled conditions of closed tracking plates not all marten and fisher will be distinguishable (see Discussion, Chapter 2). Separation of these species is much more difficult when snow is the substrate. Additionally, when snowshoe hare tracks are abundant, marten tracks (and therefore small fisher tracks) can blend in with hare tracks and these apparently distinct species can overlap sufficiently for marten (and therefore small fisher) to go unnoticed. Since snowshoe hare concentrations may draw fisher and marten, such sites along transects should be carefully examined.

The meandering behavior of hunting mustelids and overlap in

homeranges affect the number of times an individual is counted along a transect and the number of individuals producing tracks within a survey unit. Long-distance movements affect the presence or absence of an animal in a sampling unit within its homerange, thereby affecting its probability of being sampled. The last 3 factors complicate any survey method targeting forest carnivores. Though baited stations may compensate for large homeranges by drawing animals into the sample unit, they may overestimate abundance or misrepresent presence within a survey unit by drawing animals in from outside their homeranges.

Table 14. Sources of variability contributing to overall variability of snow tracking data. See text for descriptions and discussions.

1) Variation in the track-deposition intervals
2) Variation in animal activity after snows
3) Variation in snow conditions
4) Variation in observer skill to find tracks and correctly identify them
5) Difficulty in distinguishing between species
6) Meandering behavior
7) Homerange overlap between sexes
8) Long-distance movements/large homeranges

Recommendations for minimizing variability:

The time that elapses between a snowfall and the tracking survey is a major source of variability that can be minimized by restricting surveys to a narrow track-deposition interval. A minimum of 24 hrs should be allowed to provide for nocturnal and diurnal activities. This is especially important when prey species such as squirrels and snowshoe hares are considered because red squirrels are predominantly diurnal and snowshoes are predominantly nocturnal in the winter (see Chapter 1 and Mech et

al., 1966). Halfpenny et al. (1994:108) recommend tracking take place "about 2 days after a fresh snowfall". Koehler et al. (1990) tracked 24 - 36 hrs after snowfall, Litvaitis et al. (1985) tracked within 40 hrs of new snowfall, and Raine (1983) did not control for track-deposition intervals, but accounted for this factor by calculating day-km's using distance travelled and time since snow. We agree with Halfpenny et al. (1994) that 2 days is best to allow for sufficient track deposition while preventing excessive track accumulations from detracting from survey results. However, we emphasize the importance of controlling the track-deposition interval by restricting the starting time to between 36 and 48 hrs after snowfall.

Subsampling, conducting multiple surveys along the same trails, helps to account for variability associated with animal activity patterns, snow conditions, and long-distance movements. Halfpenny et al. (1994) recommend 3 surveys be conducted in each survey unit at 3 separate times throughout the winter for marten, fisher, and wolverine, and that this be repeated for 3 consecutive years or 3 of 5 winters for lynx. We feel that a minimum of 3 surveys provides a reasonable effort for marten presence (86% successful detection given that marten presence was known), but found this effort insufficient to detect fisher or wolverine. Three surveys were conducted in Bear Creek units 1 and 2 where fisher were present and 2 surveys were conducted in Big Creek units 1 and 2 where fisher were also known to exist. Snow tracking did not detect fisher in any of these units. We found also that a wolverine known to occur (more than once) in the upper unit of Sweathouse Creek was not detected after 3 surveys. Even though eight 1-mi.^{2} units were sampled in this study and multiple survey techniques provided a known distribution of target species among survey units, a reasonable estimate of probability of detection (POD) for snow tracking could only be made for marten (POD = 86%). For fisher and wolverine POD's were either very close to zero or sample sizes were so small that POD's simply could not be estimated. Although

only 1 unit had a wolverine, 4 had fishers and it seems likely that few studies in the western United States will be able to test the efficacy of snow tracking for detecting known fisher presence in more than 4 sample units. Based on the current information, we, therefore, conclude that 3 surveys are too few to determine presence or absence of fisher or wolverine within a sampling unit with any reasonable level of confidence. It is also unlikely that 3 surveys/year will give a reasonable indication of lynx presence. We recommend that subsamples be doubled to 6 per survey area within any single year and that fisher surveys be conducted for 2 years, wolverine surveys for 3 years, and lynx surveys for 3 years consecutively or 3 of 5 years as recommended by Halfpenny et al. (1994). We argue that even with such increases in sampling effort POD's for fisher may be low and POD's for wolverine and lynx they may be unacceptably low.

Because snow tracking requires skilled trackers, training is critical. Experienced personnel should take apprentice trackers into the field for several surveys to train them and to try to reduce variability in measurements and judgement calls brought about by observer variability. Indoor training will also be required since many specie's tracks are not likely to be seen during field training sessions. We suggest slides, photographs and other such visual aids be incorporated into indoor tracking programs. At least a week should be dedicated to training new trackers. A summary of these recommendations is presented below (Table 15).

Snow tracking produces highly variable results and surveys that do not control for this multitude of variability provide no more than presence/absence information and will tend to overestimate absence (i.e., miss observations). If managers wish to make inferences regarding species interactions such as predator-prey, predator-predator, and prey-prey relationships or make inferences regarding relative winter habitat use (see Thompson et al., 1989; Litvaitis et al., 1985; Raine, 1983),

Table 15. Recommendations for controlling for variability in snow tracking surveys. See text for discussion and details.

1) Control track-deposition interval. Set interval at 1 or 2 days and be consistent.
2) Variation in animal activity is best accounted for by subsampling a transect (n = 3).
3) Variation in snow conditions can be controlled through subsampling and setting minimum standards for snow tracking conditions.
4) Training time should be set aside for observers and observer testing should be undertaken to establish some conformity among observers.
5) Training observers will reduce error due to misidentification of species.
6) Meandering behavior and homerange overlap are uncontrolled variables.
7) Long-distance movements are best controlled for by subsampling and multiple sample units.

these factors must be controlled for. We strongly recommend that snow tracking surveys, even surveys currently with several years of data, change their design to reduce as much of the sampling variation described above as possible. Snow tracking surveys not controlling for these sources of sampling variation should be used only for presence/absence data. Any inferences drawn regarding habitat use and species interactions from such a highly variable data set will be unstable at best and may be erroneous. No information is lost in making such design changes, since no more than presence/absence information can be acquired from such data sets.

Ideal conditions for snow tracking include good to excellent tracking snow that persists for ≥2 days. To attain reasonable sample sizes through multiple surveys, such conditions must occur with some regularity over a given survey area and trackers must maintain the flexibility to quickly respond to these conditions. For areas such as the Bitterroot National Forest, good snow conditions are uncommon and are short-lived due to temperature

fluctuations that result in alternating freezing and thawing conditions, periodic freezing rain, and sporadic quality snowfall. Snow tracking may not afford an effective survey method where such snow condition exist.

Monitoring:

A natural tendency exists for managers implementing snow tracking surveys over a series of years to apply this method as a monitoring technique to make inferences regarding the response of rare species to forest management practices. Tracks provide a direct measure of activity, but an indirect and questionable index of individual abundance. Until the relationship between track abundance and animal abundance can be established, and the margin of error attributed to sampling variability shown to be sufficiently small (well below the true between-year variability in populations), the potential of snow tracking surveys for estimating populations and thereby providing a reliable tool for monitoring populations will remain highly questionable.

As an example, managers attempting to monitor pileated woodpeckers (*Dryocopus pileatus*) face obstacles similar to those encountered in monitoring forest carnivores; they are rare, territorial, and wide-ranging. Using criteria outlined by Verner (1986) for detecting a 10% change in pileated woodpecker populations with 95% confidence (at a statistical power of 0.80), the required sample size is estimated at 300,000 point counts per year (Verner, 1986). More important to management than the question of whether or not populations change (2-tailed test) is the question of whether or not a population is declining (1-tailed test). Monitoring for population decline requires far less effort than monitoring to detect fluctuations in a population. For example, Verner (1983) shows that a sample near 200 can detect declines of ≥25% (given moderate statistical power, 0.8) for species which occur an average of 1 time in the previous year's sample. However, this sampling effort is still exceedingly high (200 observer-days), and among forest carnivores

marten are the only species likely to approximate an average sample occurrence of 1. The larger species are far too rare to approach this level of occurrence. Therefore sample size would have to increase dramatically to correct for their low presence. Furthermore, an inability to detect a decline until it reaches 25% could be catastrophic given that populations are currently quite low for wolverine, lynx, and fisher and such far ranging species could be subject to a population threshold (Allee effect) beneath which they cannot recover (see Yodzis, 1989).

Aside from apparently insurmountable difficulties associated with sample size requirements for monitoring forest carnivores, there are basic questions about the efficacy of snow tracking as a population index. Snow tracking is highly variable. The meandering nature of tracks, homerange overlap between sexes, long distance movements, difficulty in distinguishing between some species (marten and fisher, lynx and lions), variability in snow conditions, variability in activity patterns, variability in observer skill, and variability in track-deposition intervals all combine to render snow tracking an extremely variable population index.

As a result, standard methods of quantifying tracks may provide a poor index to abundance. Koehler et al. (1990) quantified squirrel tracks by counting numbers of tracks per 100-m segment of transect. They also counted the number of squirrel middens in 10 x 100-m plots placed perpendicular to snow tracking transects. Although middens also provide an indirect index of squirrel abundance, they are less variable and hence arguably more reliable than track counts. Regression analysis of their data using square-root transformed mean track abundance on mean midden abundance produces a low r-squared term ($r^2 = 0.46$, df = 4) and indicates a nonsignificant relationship between the 2 variables ($t = 1.83$, df = 4, $P = 0.14$).

Snow tracking could be compared to a more direct estimator of squirrel abundance than middens, but there is a general dearth of information on this subject, and this example illustrates that

even detailed snow tracking data (counts per 100 m) may provide a poor estimator of abundance. Larger territorial species offer less confusion in terms of track abundance, but the greater distances travelled and the tendency of these species to meander when hunting in addition to the numerous other sources of variability discussed above render track abundance values obtained from forest carnivores similarly spurious estimators of individual animal numbers.

Becker (1991) presents 2 more refined methods of estimating populations of lynx and wolverine using snow tracking, but again these methods require intensive efforts (radio collaring and radiotracking animals or following tracks from start to finish to identify individual animals) to implement, and their many underlying assumptions are unlikely to be met in most cases. Although monitoring of forest carnivores is a high priority (see Zielinski and Kucera, 1995), the use of snow tracking to accomplish this end is more likely to lead to mismanagement than result in informative decisions.

CONCLUSIONS AND RECOMMENDATIONS

We recommend that snow tracking be used only as a survey method for determining presence/absence until the efficacy of this method for monitoring forest carnivore populations can be empirically tested. However, additional information obtainable from snow tracking surveys beyond presence/absence include relative winter habitat use (Thompson et al., 1989; Litvaitis et al., 1985; Raine, 1983) and potential predator/prey and other interspecific interactions. If multiple surveys within and/or between years continue to detect rare carnivores in a sample unit, such data suggest important habitat use within that unit such as foraging or denning as opposed to 1-time presence which can result from transient use due to nomadic behavior. Multiple detections within a unit therefore may provide managers with more robust "presence" data on which to base management decisions. This may be an important consideration when designing snow

tracking surveys.

Multiple surveys should be conducted on each transect to allow for variability in activity patterns, snow and weather conditions. The practice of determining whether a track should be counted or not based on an observer's subjective opinion as to whether the track is from an a meandering animal recrossing the transect should be restricted using the following criteria. If a track can be seen from the transect to recross the transect it should not be counted again. If a track crossing the transect leaves the observer's view and "apparently" recrosses the transect it should be counted as a separate track. Since snow tracking is an index to activity, this approach is appropriate, and if snow tracking is used for other purposes, following these guidelines will make the method more consistent and robust.

We recommend that measurements be taken on 5 prints or gaits rather than 3 as suggested by Halfpenny et al. (1994) due to the variability associated with making these measurements. The additional measurements do not require much additional time or effort. Minimum outline measurements should be made instead of variable outline because they are more consistent and using 1 measurement allows for comparison between measurements. Measurements need not be made on consecutive prints. Variability in measurements is reduced by following the trail and finding the best prints on flat substrates.

Qualitative characteristics of trails such as gait, pattern, and behavior also provide important clues to track identification. Fishers in this study predominantly used the 3x gait associated with a gallop whereas marten tended to bound using the 2x gait. Fisher also walked much more than marten did and bounding was used primarily in deep snow. Raine (1983) quantified the time fisher and marten spent using each gait and found very similar results. Such qualitative information may be crucial to distinguishing female fisher and male marten in the zone of overlap, but this needs to be evaluated further using individuals of known species and sex and quantifying results

using discriminant function analysis.

Coyotes and lions often travelled in pairs or threes and walked in single file, especially on narrow trails. Registration of tracks was nearly exact between individual lions so that 3 animals appeared to be 1 until they switched from a travelling mode to a hunting mode and split up. Coyotes also often travelled with individual animal's tracks registering directly in those of the animal before them, but did so less so. Both species crossed creeks on narrow, high snow-covered logs with apparently little difficulty and coyotes often walked on logs when travelling through the forest. This behavior distinguishes coyotes from all but the most agile domestic dogs. Qualitative traits are discussed further by Halfpenny and Biesiot (1986).

We offer variations on the data sheets presented by Halfpenny et al. (1994) to accommodate recommendations made here and to better facilitate their use in the field. We have condensed the "Track Observation Form" (Halfpenny et al., 1994:172-173) into a single page to simplify its use in the field and have replaced the mean and standard deviation columns with columns for 2 additional print and gait measurements. We added locations for recording "Snow depth and substrate" and type of "Gait" because we feel this is critical information. We also added lines for indicating whether or not prints were casted or photographed and, if photographed, the roll number and frames so that the measurements could be linked to any permanent records made. Lines at the bottom of the sheet provide a place to record when the date data was entered into a data base and error checked and by whom.

The column "Foot" is included so that footedness can be recorded. Print measurements will vary less if taken from the same foot. In taking more precise measurements from tracking plates we found that feet may differ in size thereby adding to the overall variability of measurements when footedness is not accounted for.

The primary change made in the "Snow Tracking and Habitat

Form" was to increase its width and add additional columns so that a column could be assigned to each of the target species (except for lynx which still shares a column with other felids). We found a single column did not allow sufficient room for weasels, marten, fisher, and wolverine given the abundance of marten and weasel tracks. Similarly we provide 2 separate generic columns for prey species, "Prey 1" and "Prey 2", and another column , "Other", for an additional prey species or other category such as domestic dogs and cats or humans if these are of interest. Specific prey species can be assigned to "Prey 1" or "Prey 2" at the bottom of the form. Snow tracking surveys may provide an effective method of determining winter use by humans in some areas. This information may be valuable to managers for a variety of reasons. We substituted the categories "Unit" and "Section" for "Time" and "Distance from start" in the first 2 columns because these are more conducive to the protocol outline using the 2-mi.^{2} sample unit. However, preference between these categories will vary depending on how surveys are conducted (long transects versus sections within units).

Track Observation Form

Date/time _____ Database # _____

Species _____ Confirmed(?) _____
Location _____
Legal description: Township _____ Range _____ Section _____
UTM _____ Elevation _____ Topography _____

Habitat _____

Snow depth and substrate _____
_____

Gait _____ Observer(s) _____

Casted? ____ Photographed? ____ Roll # _____ Frames _____

	Trail Measurements				
	1	2	3	4	5
Stride					
Group					
Straddle					
Trough					

	Foot	Print Measurements				
		1	2	3	4	5
Front length						
Front width						
Hind length						
Hind width						
Metatarsal						

* Note: Measurements should be made on the same foot. Indicate which foot was measured (L or R) in first column.

Data entered by _____ Date _____
Error checked by _____ Date _____

Snow Tracking and Habitat Form

Observer_____ Date_____ Sheet____ of____ Sample Unit number_____

Days since last snow_____ Survey area_____
General comments_____
_____

Unit	Sect.	*Gulgul*	*Marpen*	*Marame*	*Mustex*	Felidx	Canidx	Prey 1	Prey 2	Other	STQ	Habitat	Comments

Gulgul = wolverine; *Marpen* = fisher; *Marame* = pine marten; *Mustex* = weasels (i.e., any species of the genus *Mustela*); Felidx = any species of the family Felidae; Canidx = any species of the family Canidae; Prey 1, 2 and "Other" to be identified by the observer. Describe the snow tracking quality (STQ) using the chart on the back of this page. Use asterisks and comments to indicate individuals for which measurements, photos or plaster casts were obtained.

Data entered by _____ Date _____
Error checked by _____ Date _____

GENERAL SUMMARY AND CONCLUSIONS

It is important to reiterate at the beginning that all of the methods considered here must be viewed as primarily providing presence/absence information. Indeed, non-detection does not even necessarily mean absence. As Zielinski and Kucera (1995) emphasize, the primary objective here is one of detection. The reality of this fact becomes even more apparent when one considers a recent, well designed study, where actual population numbers were known and controlled for while the efficacy of a tracking method was studied. Smith et al. (1994) manipulated an island population of raccoons in Tennessee, altering the number of individuals while at the same time monitoring their activity by radiotelemetry. With the number of individuals and their locations known, they attempted to estimate population size over a 27 month period, by visitation activity at scent-stations (comparable to activity at baited tracking plate stations in the present study). When the exact number of raccoons was known (n = 40) their population estimates based upon scent-station visitation ranged from 0 to 286! The variability in scent-station hits observed which led to such inaccurate population estimates was primarily attributable to seasonal variation in visitation rates due in part to changing home range sizes, temperature influences (cold temperatures restricted movements and thus visitation), and disproportionate representation of habitat types by the scent stations. The authors found (1994: 644), "...no indication of a relationship between visits to scent stations and population size...", and concluded that this method should not be used as an index to population density. If we solely consider remote-sensing cameras, tracking plates, and snowtracking methods as procedures for detection, all three methods may work well given appropriate conditions, though the cost incurred, effort involved in there use, and associated biases must be carefully considered.

In our study use of remote-sensing cameras proved to be the

are designed so that cameras are easily accessible by road, the Trailmaster® system is preferable over the Manley camera. Weight considerations, the potential for 12-volt battery leakage with the Manley system, and repair problems which a larger manufacturer can deal with more expediently, favor equipment like the Trailmaster® product.

Of the two methods which consider track analyses, tracking plates generally provided less ambiguous impressions than were found under most circumstances where snowtracking was employed. Costs for tracking plate construction are minimal allowing many units to be placed throughout a study area. Man hour investment, though greater than for remote-sensing cameras, is generally less than that required to employ snowtracking effectively. The biases discussed in Section 2 above, become more important where marten and fisher are found in sympatry. It is very important to recognize and accept the current limitations inherent in this method when attempting to distinguish between male marten and female fisher. Even here however, the evidence provided by sooted tracks is more discernable than most snow impressions. When weather conditions are conducive to the use of open tracking plates latency to detection may be very short. The effectiveness of this method has yet to be shown for wolverines and lynx.

Unfortunately the method which we feel is least effective at providing reliable information for the species of concern is the one most often employed by agency personnel. Given ideal snow conditions and well-trained individuals with considerable experience, we accept that this method will provide useful information. However, in a majority of localities as exemplified by most of western Montana, snow conditions/snow quality are highly variable. One can be presented with a wide range of snow conditions over the course of a few hours on a single day within a single drainage. Furthermore, an animal's behavior is highly influenced by local and current conditions such as temperature, wind, and other variables beyond the researcher's control. In order to even begin to lessen these problems multiple surveys

with subsampling must be built into any experimental design. However, when this is done the number of man hours required to use this method increases dramatically. Though discussed in detail in Section 3 above, we feel that it is also important to again emphasize that snowtracking is only effective when used by individuals having significant training and experience in interpretation of such information. The quality of the data collected is directly related to an individual's experience; and such experience is often difficult to obtain in regions where snow conditions are generally poor and the number of surveys conducted per year are limited. Appropriate training, the willingness to trace a snow path for often a considerable distance before a clear impression is found, and the willingness to dismiss poor quality, questionable tracks, have to be met before evidence from this method can be routinely accepted.

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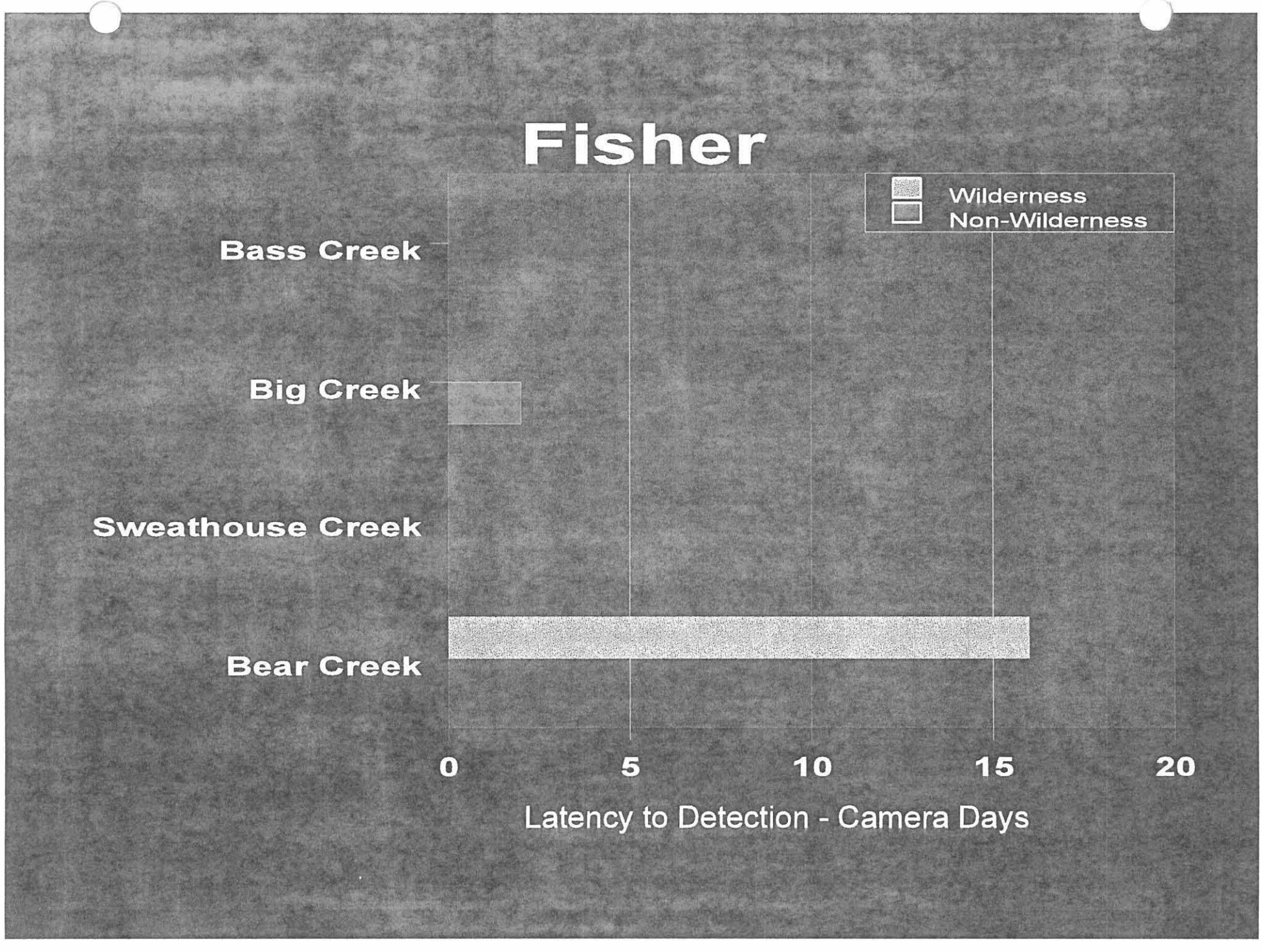
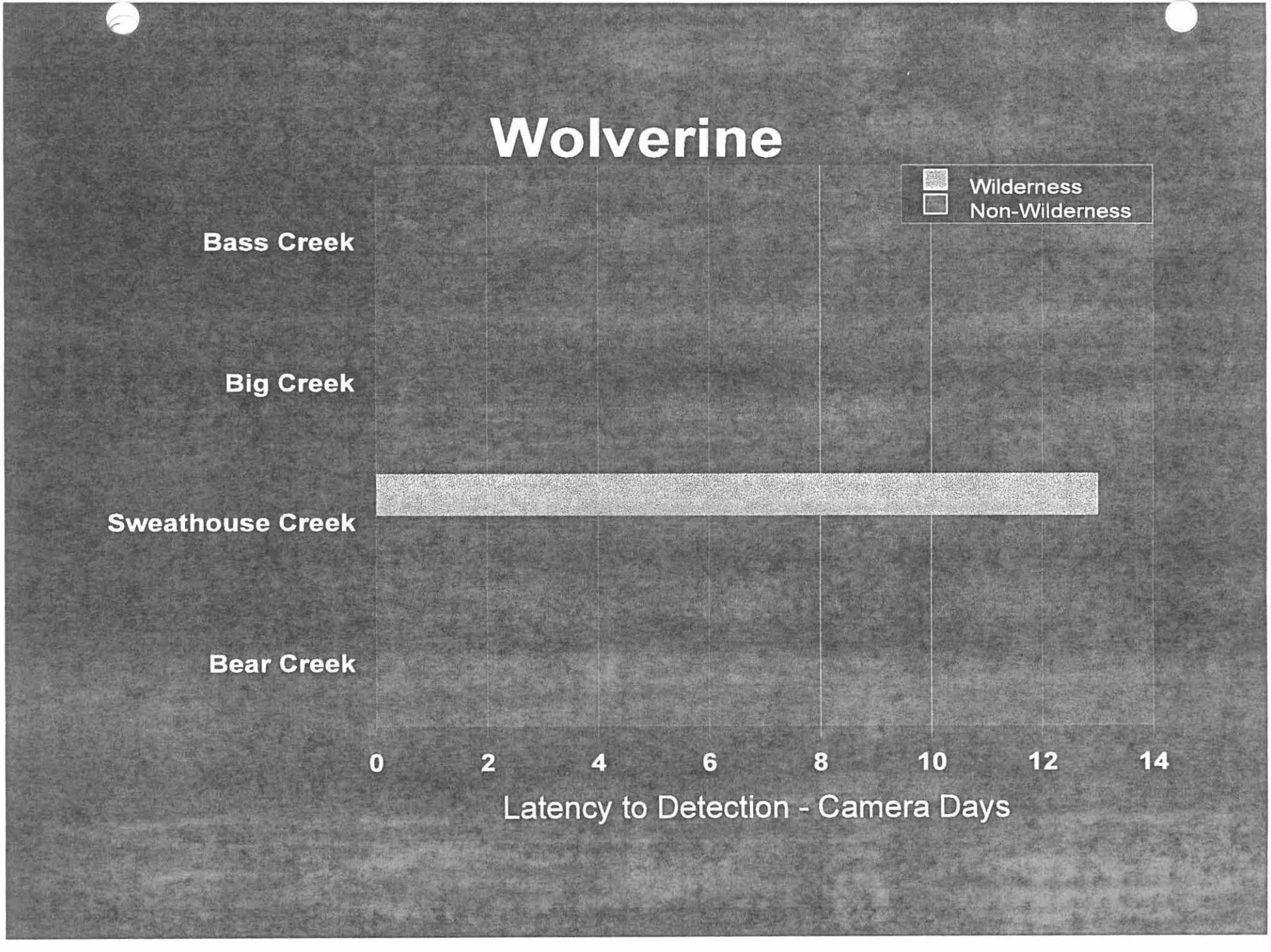
APPENDIX 1. Camera latency to detection graphics for martens, fishers, and wolverines.

American Marten
Wilderness
Non-Wilderness
Bass Creek
Big Creek
Sweathouse Creek
Bear Creek
0
10
20
30
40
50
Latency to Detection - Camera Days


Fisher
Wilderness
Non-Wilderness
Bass Creek
Big Creek
Sweathouse Creek
Bear Creek
0
5
10
15
20
Latency to Detection - Camera Days


Wolverine
Wilderness
Non-Wilderness
Bass Creek
Big Creek
Sweathouse Creek
Bear Creek
0
2
4
6
8
10
12
14
Latency to Detection - Camera Days

Lynx rufus *							x					
Cervidae												
Odocoileus virginianus	x											
Alces alces	x						x					
Bovidae												
Oreamnos americanus ᵛ												

ᵛ = visual observation only.

Canis lupus observation was based on behavior and measurements from tracks in snow. See text for discussion and Appendix X for measurements.

Mustela erminea observations were confirmed to genus based on snow tracks and tracking plates. The assumption was made that the species was *M. erminea* based on habitat.

Lynx rufus observation was difficult to confirm to species. This may also have been a juvenile *Felis concolor*.

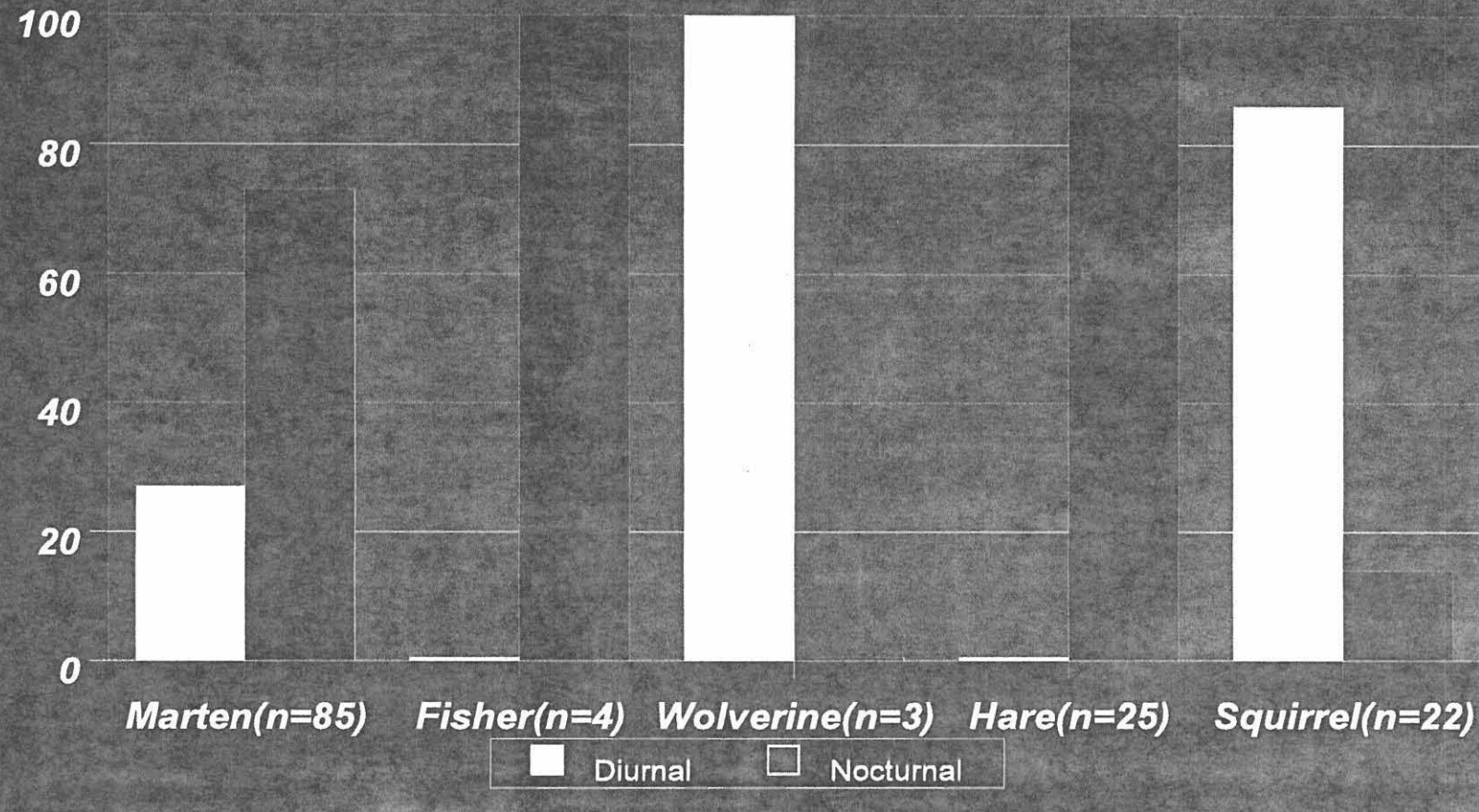
APPENDIX 3. Graphic of camera monitoring efficiency.

Camera Monitoring Time

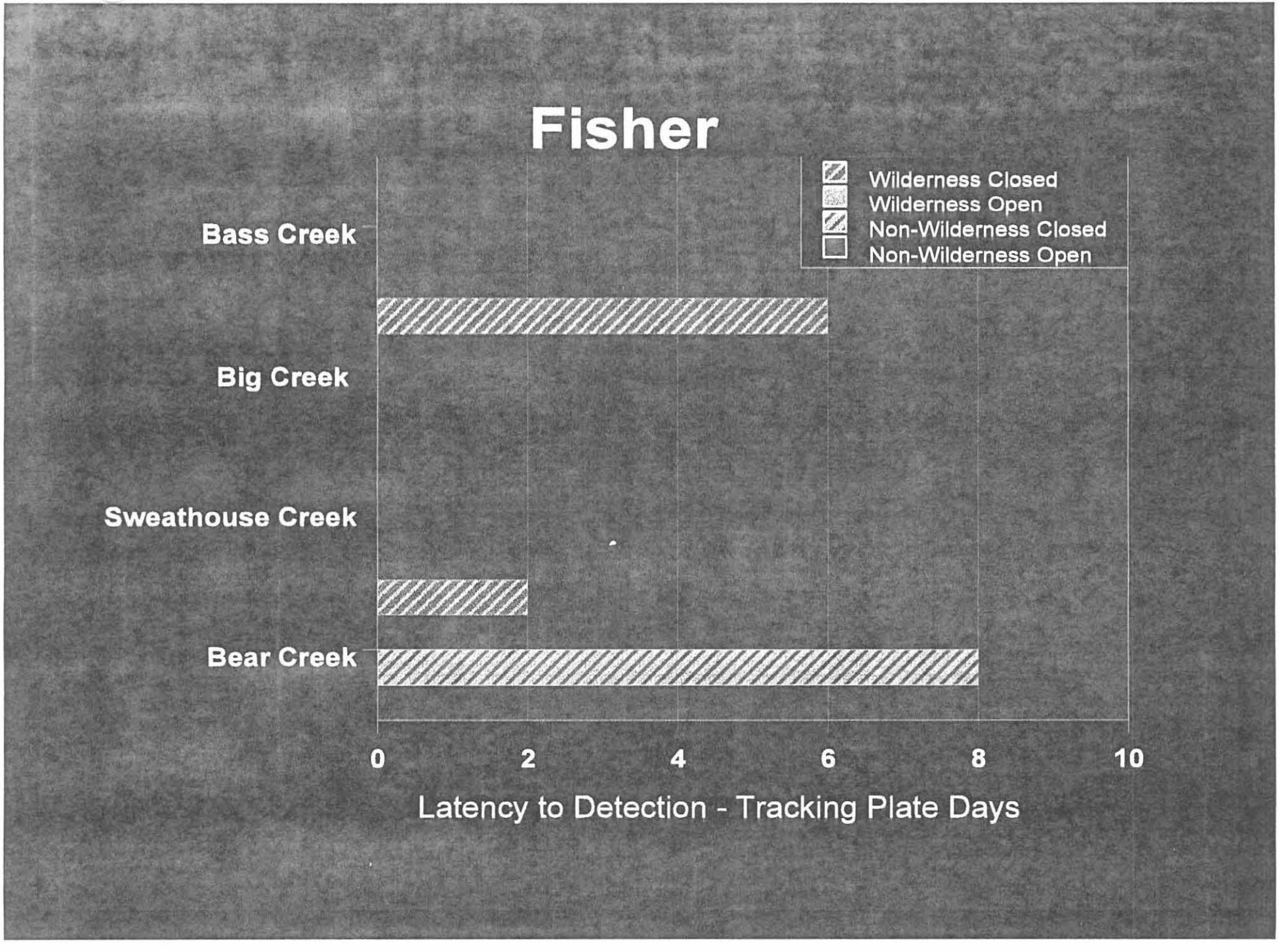
APPENDIX 4. Graphic of activity patterns for martens, fishers, wolverines, snowshoe hares, and red squirrels.

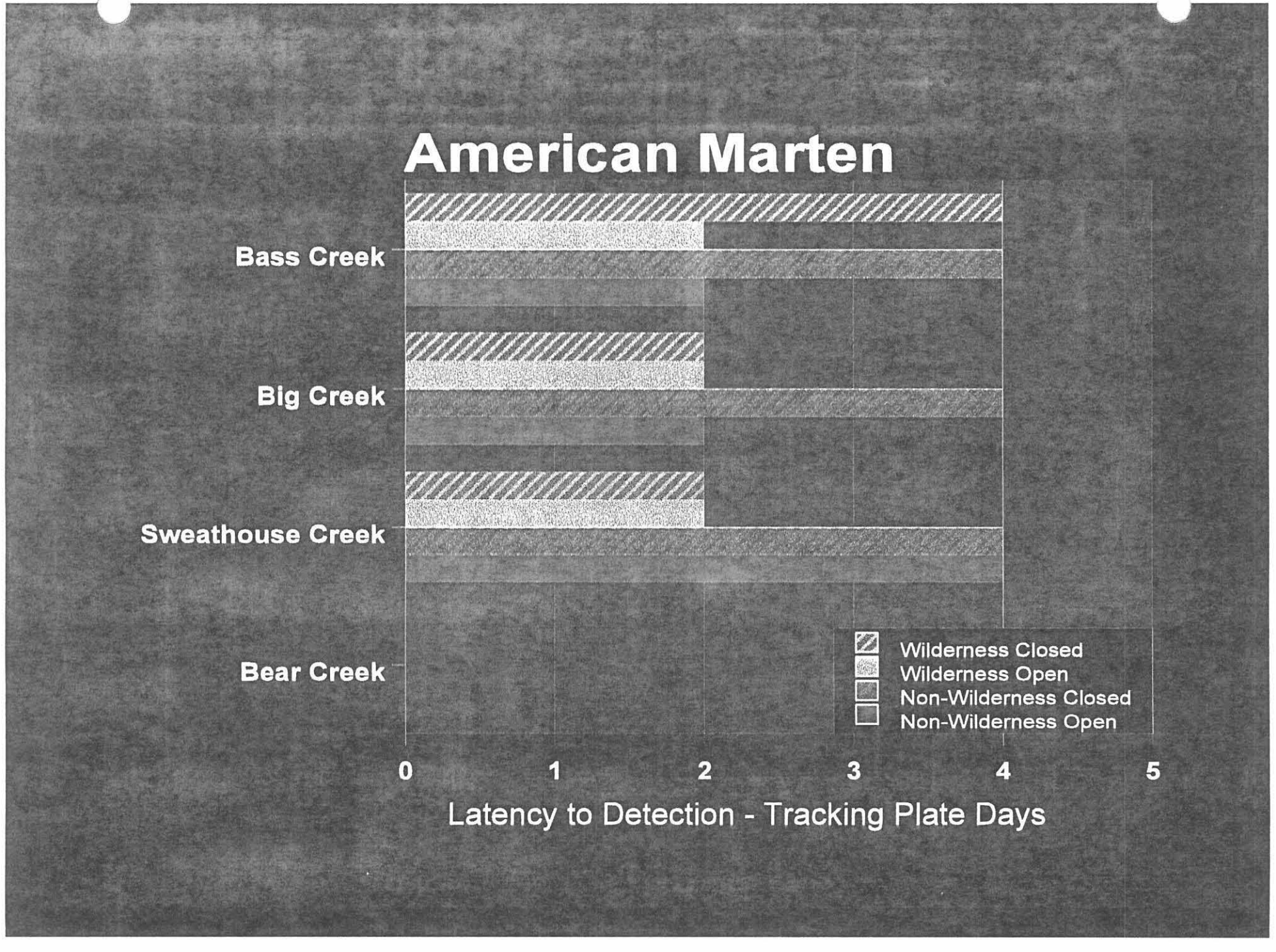
Activity Pattern

% of Observations



APPENDIX 5. Tracking plate latency to detection for fishers and martens.


Fisher
Wilderness Closed
Wilderness Open
Non-Wilderness Closed
Non-Wilderness Open
Bass Creek
Big Creek
Sweathouse Creek
Bear Creek
0
2
4
6
8
10
Latency to Detection - Tracking Plate Days


American Marten
Bass Creek
Big Creek
Sweathouse Creek
Bear Creek
Wilderness Closed
Wilderness Open
Non-Wilderness Closed
Non-Wilderness Open
0
1
2
3
4
5
Latency to Detection - Tracking Plate Days

APPENDIX 6

Fisher track measurements obtained from prints made on contact paper collected from closed tracking plates.

				Print measurements										
Creek	Unit	Station	Date	WI3	LI3	LI4	DF score	L1	L2	L3	L4	W1	W2	Ft
Bear	1	5	5/02	17.18	13.12	13.66	52.31	78.50	61.27	54.68	46.72		43.42	R
Bear	1	5	5/04	17.78	14.56	13.64	59.58	79.10	62.10	57.47	49.97	48.46	46.39	R
Bear	2	8	4/28	11.81	7.80	6.45	4.36			42.45	36.01		27.83	R
Bear	2	8	4/30	17.62	14.01	13.43	56.92			56.59	49.19	46.09	42.85	R
Bear	2	8	5/02	19.29	13.88	12.65	63.48	81.99	63.37	58.29	50.33	51.14	45.45	R
Bear	2	8	5/02	16.51	12.35	15.32	48.31	74.41	57.80	51.39	42.01	42.32	39.57	L
Bear	2	8	5/04	15.98	11.85	13.98	43.09			48.50	39.65	42.59	42.59	L
Bear	2	8	5/04	14.24	10.98	14.60	32.92			48.82	38.30		41.37	L
Bear	2	9	5/02	12.26	8.53	6.94	9.17			43.91	36.67	34.09	31.26	L
Bear	2	9	5/02	11.44	9.03	7.56	7.51			41.42	34.77	31.91	30.96	R
Bear	2	9	5/04	15.14	12.55	10.70	38.46			48.46	40.91	39.87	38.82	L
Bear	2	9	5/04	12.57	9.97	7.61	15.73			41.59	36.46	32.67	31.97	R
Bear	2	12	4/26	14.10	9.76	7.87	22.34			42.68	36.95		29.61	L
Bear	2	12	4/30	15.87	14.26	13.70	49.91			50.32	42.22		41.18	L
Bear	2	12	4/30	13.85	9.23	8.44	20.04			44.99	37.92		30.95	R
Bear	2	12	5/02	17.55	13.34	13.42	54.48			49.41	39.52	41.21	40.66	L
Bear	2	12	5/02	14.29	8.93	8.62	21.28			43.69	35.45		30.06	R

APPENDIX 6 (cont.)

				Print measurements										
Creek	Unit	Station	Date	WI3	LI3	LI4	DF score	L1	L2	L3	L4	W1	W2	FL
Bear	2	12	5/04	13.15	10.24	8.62	20.16			41.49	34.91	35.81	33.50	R
Big	2	11	5/03	13.13	8.26	7.79	13.09	71.93	51.93	41.24	34.49	33.56	32.25	R
Big	2	11	5/03	10.41	8.17	8.75	1.18			40.83	35.30	32.22	31.62	R
Big	2	11	5/03	12.97	8.10	6.71	10.87			40.22	34.24		30.20	L
Big	2	11	5/03	12.47	8.60	7.93	10.89			38.91	33.33		31.26	L

APPENDIX 7

Marten track measurements obtained from prints made on contact paper collected from closed tracking plates.

				Print measurements										
Creek	Unit	Station	Date	WI3	LI3	LI4	DF Score	L1	L2	L3	L4	W1	W2	M
Sweat	1	6	5/28	6.84	5.91	4.77	-25.94			29.15	23.91		20.10	L
Sweat *	2	7	5/30	9.62	6.82	5.05	-10.05		40.72	31.66	24.88	27.04	23.51	R
Sweat	2	7	6/03	7.39	5.91	5.19	-23.03			28.96	23.31		22.57	L
Sweat	2	7	6/13	7.58	6.40	5.38	-20.45			30.39	24.92		23.24	L
Sweat	2	10	6/01	6.20	5.64	4.21	-30.24			27.45	22.93		19.57	L
Sweat	2	10	6/13	7.59	6.18	3.92	-22.42			26.25	22.96		19.24	L
Sweat	2	11	6/01	6.55	5.71	4.89	-27.79			28.40	23.61		21.73	R
Sweat	2	11	6/13	6.80	5.05	3.21	-30.24			26.40	22.51		20.00	L
Big	2	7	5/03	6.39	5.62	4.48	-29.18			31.94	26.56		27.20	R
Big	2	10	5/01	4.77	5.25	3.63	-38.56			29.38	24.25		24.04	R
Big	2	10	5/03	7.62	5.79	4.75	-22.75			28.75	23.95		24.22	R
Big	2	10	5/05	4.67	4.24	2.10	-43.58			26.89	22.66		22.96	R
Big	2	10	5/09	8.61	6.19	5.92	-15.88			30.51	25.03		23.73	R
Big	2	10	5/07	5.99	5.65	4.20	-31.18			29.95	24.77		24.42	R
Bass *	1	1	5/25	7.89	6.14	5.11	-20.08			30.50	26.42		22.84	L
Bass	1	2	5/29	6.03	4.97	3.85	-33.45			27.14	23.13		24.14	R
Bass *	1	5	6/02	5.18	5.29	4.60	-35.63			30.19	25.42		22.71	

Creek	Unit	Station	Date	WI3	LI3	LI4	DF Score	L1	L2	L3	L4	W1	W2	Ft
Bass	2	7	5/27	9.15	6.39	4.33	-14.21			32.14	28.08		25.85	R
Bass	2	7	5/29	7.62	6.22	5.61	-20.62	46.26	37.88	33.85	29.05		25.36	L
Bass	2	7	5/31	8.02	6.64	4.36	-18.59			32.69	28.01		23.09	L
Bass	2	7	6/02	8.52	6.55	4.77	-16.21			32.05	27.41		24.25	L
Bass	2	7	6/04	5.51	5.10	4.74	-34.63			30.14	24.44		21.68	R

APPENDIX 7 (cont.)